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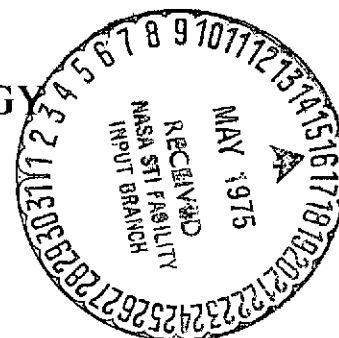
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TECHNOLOGY ASSESSMENT OF PORTABLE ENERGY RDT&P PHASE I

Compiled by
J.R. Spraul

TRW SYSTEMS AND ENERGY



Prepared for
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA Ames Research Center
Contract NAS 2-8445
A.D. Alexander, III, Project Manager

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FINAL REPORT
TECHNOLOGY ASSESSMENT OF PORTABLE ENERGY RDT&P
PHASE I

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

April 7, 1975

CONTRACT NAS 2-8445

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1. PROJECT OVERVIEW AND SUMMARY

1. PROJECT OVERVIEW AND SUMMARY

This report covers the work performed on Phase I of a planned three-phase program under the direction of the Systems Studies Division of NASA's Ames Research Center. The general objective of the program is to undertake a technology assessment of portable energy research, development, technology and production to assess the technical, economic, environmental and socio/political issues associated with portable energy options. A further objective is to determine those courses of action impacting aviation and air transportation research and technology. A more specific objective of the Phase I program is the generation of appropriate problem statements for the critical study tasks defined in the Phase I program.

The methodology used to achieve the objectives of Phase I involved a seven-step program plan. Task 1 called for the establishment of an initial information base. This was a continuing activity throughout this program, and copies of all items entered into this information base have been transferred to the NASA Ames Research Center. A description of the computerized method for index compilation and use of the information base is discussed in Section 2.1 of this report. The second task of the program plan required the compilation and assessment of current policies, programs and issues relating to portable energy, and the development of possible portable energy scenarios for the 1980's and 1990's. Two actions were taken to satisfy this task, the first of which involved the writing of suggested potential actions (alternative fuels processes), and the second was the scenario development. This latter activity was the prime responsibility of the Energy Research Center of the University of Texas at Austin, the co-contractor of this program. Both the potential actions and the complete scenarios were published in the Workshop Results Review Report and are not presented again in this Final Report. Summaries of the scenarios are given in Section 2.3, Workshop Results, Conclusions and Recommendations.

The organization and administration of a Portable Energy Technology Assessment Workshop was the requirement of Task 3. Details of this effort are given in Section 2.2.

The workshop involved 38 participants and was held in Monterey, California, during the last week in August 1974. The workshop operation was supported by appropriate personnel from NASA, the University of Texas and TRW. During the course of the technology assessment workshop, the participants were placed in 12 working groups. For the first day and a half six working groups were used in which the participants were divided generally according to homogeneous backgrounds and interests. For the rest of the week a different set of six working groups was used with a heterogeneous mixture of participants. Each of the 12 working groups prepared written reports which included over 80 conclusions, recommendations and items of interest. The workshop participant group reports can be found in Section 2.3. Some important general conclusions of the workshop participants were that there is no simple answer to the portable energy problem and further that no simple approach or philosophy will yield satisfactory results. For example, an all-out domestic energy production effort was not considered to be reasonable by the workshop.

As called for by the work statement of the contract, a workshop report was prepared and issued to satisfy Task 4. This workshop report was published at the end of October 1974 and included the information base references up to that time, the information and data sent to the participants before the workshop, the workshop participant group reports, including minority reports, and a critique of the workshop by the participants as well as NASA, University of Texas and TRW personnel.

The results of the workshop were reviewed as the activity of Task 5. This review was a five-step process leading to the writing of problem statements, which is the final objective of Phase 1 of this program. First, the conclusions, recommendations and items of interest of the workshop participant groups were compiled. From this list of over 80 items, a number of which were closely related or overlapping, candidate problem statement titles and a brief description of the subject areas were prepared. Forty-seven problem statement titles resulted from this activity. As a third step each of these 47 subject areas were explored against information in the data base, conversations with selected participants, NASA criteria and knowledgeable people at NASA, TRW and the University of Texas. Three basic NASA criteria used are:

- Must be relevant to NASA (a) Aviation R&T, (b) Transportation R&T, or (c) Energy
- Issue not adequately addressed elsewhere
- NASA/Industry/Universities have the competence to address the issue.

This exploration of 47 candidate problem statement subject areas eliminated a number of areas that were considered outside of NASA's interests or well covered by other agencies, industries or previous technical work. This resulted in the final subject area, listing of 18 problem statements which were prepared and given in Section 5 of this report. A more detailed discussion of the philosophy and problem statement development described immediately above is in Sections 3 and 4 of this report. Task 6 covered the preparation of the problem statements as described above, and Task 7 of the program plan covered the writing of Phase I Final and Summary Reports of which this document is the former.

The 18 problem statements are compiled in Section 5 of this report. Seven of the 18 are particularly relevant to NASA's aviation research and technology and are briefly described below.

Study to Determine the Availability of the Most Probable Aviation Fuels

Coal and oil shale are prime energy resources, but offer no direct possible use as aviation fuels. There are many questions concerning their successful extraction and conversion into useful fuels that remain unresolved. These questions involve not only technical and economic considerations, but also important related issues such as environmental impact, labor supply and training, extraction and conversion safety, and the broad question of the respective roles of government and industry.

The principal objective of this study is to describe the most probable aviation fuels in the 1980's and 1990's, and to determine the feasibility of providing an adequate supply of hardware-compatible aviation fuels derived from domestic coal or oil shale at stable competitive prices within this time frame.

An Analysis of Institutional and Associational Barriers to the Implementation of New Portable Fuel Sources

When implementation of new portable fuel sources is critical to the transportation function, it is vital to analyze and understand the barriers to such changes. These barriers may be sought under two major headings. First, institutional barriers arise when change confronts the complex of customary practices in a given area. Second, associational barriers form when proposed changes violate the interests of particular groups. The proposed study would identify institutional and associational barriers to specified changes in portable fuels sources, and, on that basis, would analyze possible means for overcoming such barriers.

A Systems Analysis of the Energy Costs Related to the Design, Manufacture and Use of Aircraft

The objective of this proposed project is to determine the energy cost associated with the design, manufacture, certification and use of aircraft with the eventual objective of identifying opportunities for the conservation of energy and other natural resources.

Test Synthetic Fuels to Assure Reliable Operation in Aircraft Engines

In the 1980's and 1990's it is expected that a number of synthetic fuels will be offered for aircraft use. Even though there will be detailed physical and chemical characterization of the synthetic fuels, this is not considered to be sufficient assurance. There have been reported and documented examples of unreliable aircraft operation due to changes in refining methods of petroleum products. This project proposes to assure reliable operation through the testing of the synthetic fuel in actual aircraft engines, including the fuel storage and handling system.

Develop an Approach to "Generating an Industry" to Manufacture, Market and Use New Synthetic Liquid Fuels

The traditional reasons for the development of new industries may not be present in the next 25 to 50 years as a force to introduce new synthetic liquid fuels; nevertheless it will be important that such an industry exists. This work statement covers the effort needed to explore various

available alternatives and to develop an approach to "generating an industry" which will manufacture, market and use new synthetic liquid fuels.

Direct Conversion of Coal to Light Aviation Fuel

Most programs presently being considered for the conversion of coal to portable energy fractions propose the production of a synthetic crude which then is treated in more or less conventional refineries to obtain fuels compatible with current engines. The direct conversion of coal or one of its gasified products to light aviation fuel is technically feasible. This basic approach generally is being ignored at the present time but should be reexamined and updated to assure that this inherently attractive route to portable energy for aviation use is explored.

Automation Systems for Drilling Rigs

An increase in the number of drilling rigs in the United States would assure additional drilling and thus an additional amount of petroleum derived fuels. One method to effectively increase the number of drilling rigs would be to automate as many of the drilling operations as possible. A work statement in this subject area has been developed with the belief that NASA' sensor and control technology could contribute to such a project for the national benefit.

The following problem statements have been prepared on subject areas relating to general transportation research and technology that could have impact on aviation fuel development but not as directly as the five problem statements listed above.

Develop New Approaches to a Better Hydrogen Supply for Synthetic Liquid Fuel Development

The basic problem of creating liquid hydrocarbons from coal is one of adding hydrogen to the coal under the influence of temperature and pressure. The cost and the quality of this hydrogen raw material will have significant impact on the availability and price of new synthetic liquid fuels for aviation applications. This problem statement defines a program to analyze alternative methods for manufacturing gaseous hydrogen to be used in the preparation of new liquid synthetic fuels.

Specification for the Production of Alternative Scenarios by Simulation

The production of alternative scenarios by simulation (PASS) method, which utilizes a technique similar to war gaming, would be used to generate predictions of possible sequences of events resulting from the adoption of a given governmental policy with respect to energy. A simulation team would be assembled consisting of individual experts in a variety of areas. The scenario simulation would be started by defining a set of initial conditions and a set of constraints that would govern future decisions. Each of the experts would respond by predicting the reaction of his particular interest group. The objective of this proposed study would be to test the workability of the simulation approach for energy-related scenario generation.

Social-Demographic Influences on the Demand for Air Transportation

Economic, social-demographic, and environmental influences are known to affect the demand for air transportation, but the specific kinds of influences within these broad categories remain to be determined. This study program would have as its objective to identify major influences on the demand for air transportation and to establish quantitative means for projecting changes in that demand.

Develop Approaches and Identify Application Areas for Small-Scale Conversion of Wastes to Power or Synthetic Fuels

More than 2 billion tons of organic wastes are generated in the United States each year. Only a relatively small proportion of this waste, approximately 25%, is readily collectible at the present time. Generally, this is waste usually collected by large cities. Several cities are now burning this waste to produce heat and power, and some plants are being built or planned for the production of fuel from garbage by pyrolysis. A major share of the waste is available in relatively small quantities, but nevertheless these quantities are sufficient to consider as raw material sources. Examples include municipal governments, agricultural cooperatives and cattle feedlots. This work statement proposes activities that would tap the smaller size volumes of organic waste which could theoretically supply as much as 1 million barrels a day of synthetic liquid fuels.

Seven problem statements for projects in the general field of energy development have been prepared. Each subject area defines a program that would improve our general energy supply and thus directly or indirectly give higher assurance of portable energy availability.

Evaluate Hydraulic/Solvent Methods
for Safely Increasing the Mining of Coal

The concept of the use of a liquid fracturing system for underground coal mining is not new; however, none is known to exist in the United States. Since this mining method holds the promise of improving the safety conditions in the underground mine within the present-day economics, it is worthy of consideration. Coal, of course, is the major raw material presently being considered for use in processes to develop synthetic fuels. The prime objective of this proposed program is to determine if this alternative underground mining technique is a real and potentially valuable alternative to presently used mechanical methods.

Relationship Between Energy Load
Demand and Geothermal Resource Areas

The rapid development of the geothermal resources of the United States would help assure the availability of portable energy fuels. One requirement for accelerating this geothermal development is not presently being addressed. This proposed problem statement would define the total energy demand in the general area of high potential geothermal resources so that the public utilities or other organizations could develop plans for geothermal resource utilization.

Design Study for a Solar Energy Concentrator

Inexpensive optical/mechanical systems for the concentration of solar energy for the purpose of producing electrical power are needed if this energy source is to be fully exploited. Other solar energy applications such as space heating and air conditioning, water heating and high temperature furnaces are receiving significant attention. Installations for the production of power need attention. This problem statement covers that requirement.

Thermoelectrics for Commercial Power/Process Plant Energy Augmentation

The exhaust stacks from commercial power or processing plants contain a large quantity of low-grade heat. Although thermoelectric devices are not highly efficient, their use in exhaust stacks would not require moving components and should not significantly increase the pressure drop. State-of-the-art thermoelectric devices are suitable for this application. The program proposed is designed to determine if this relatively simple method can augment our energy supply with reasonable economics.

Application of NASA Sensor and Teleoperator Technology to Improved Mining and Mineral Resource Technology

One means of contributing to the safe and productive exploits of underground mineral resources is to operate the underground mining machinery and related transport equipment remotely. NASA has made a significant contribution to sensor and teleoperator technology, and this problem statement covers an activity to develop concepts for systems suitable to perform mining operations remotely.

Evaluate Mechanical, Physical and Chemical Methods of Energy Storage

Energy often is either available or needed at the wrong time, in the wrong place or in the wrong form or quality. Many of these supply/demand mismatches of time, place, form and quality could be alleviated by appropriate methods of energy storage. This problem statement covers a program to evaluate current and proposed mechanical, physical and chemical methods of energy storage in order to establish future research and development goals.

Delineation of Potential Societal Dislocations Resulting from Efforts to Establish Energy Independence in the United States

There is an enormous potential for social, economic, political, and demographic dislocations if the United States elects to mount a major effort to become self-sufficient with respect to energy production. This program would specify the parameters most likely to be impacted by a program such as Project Independence. Cross-impacts and direction of relationships also will be specified. The approach will involve bringing

together and synthesizing both existing analyses and some original studies of the energy needs, productive potential and delivery systems of the United States in order to predict the dislocations that can be expected to occur with a full-scale effort to reach energy independence. This approach then will be used to analyze population movements resulting from changes in energy generating facilities in the U. S.

These 18 problem statements are recommended for NASA's consideration as part of their specific contribution to aviation research and technology and, more generally, to the national energy requirements.

2. PORTABLE ENERGY TECHNOLOGY ASSESSMENT

2. PORTABLE ENERGY TECHNOLOGY ASSESSMENT

This section deals with the technology assessment portion of the project, or essentially the first half up through the publication of the Workshop Proceedings Report. A data base was established at the beginning of the program and used throughout. A description of this activity and the products from it are discussed in Section 2.1. Preparation and Operation of the Workshop are discussed in Section 2.2. Written reports by the 12 working groups of interdisciplinary participants attending at the Monterey conference were the main product of that meeting, and they are presented in Section 2.3 along with summaries of the working groups' conclusions, recommendations and selected directions.

2.1 ESTABLISHMENT OF THE PROJECT INFORMATION BASE

An information base was established for the support of subsequent investigations for the Technology Assessment of Portable Energy Project. The effort involved both the acquisition of pertinent information and data, and the utilization of a computer based document control system, which made the information quickly and readily available to the TRW, NASA, and University teams.

TRW systematically reviewed its in-house data and utilized established contacts in the industrial, consumer, government, and university sectors to obtain additional information as required. The accumulation of data continued during the course of the project in order to remain cognizant of new information as it became available.

2.1.1 Scientific Document Control System

During the performance of the Technology Assessment of Portable Energy Project, the TRW Document Control System was utilized in the establishment of the project information base. The system utilizes a combination of several interrelated computer program modules. An illustration of how the system was used on the project is presented in Figure 2-1.

All data pertinent to the project were filed and indexed in a manner which made retrieval of information on a particular subject very easy. The computerized system enabled document retrieval from the central

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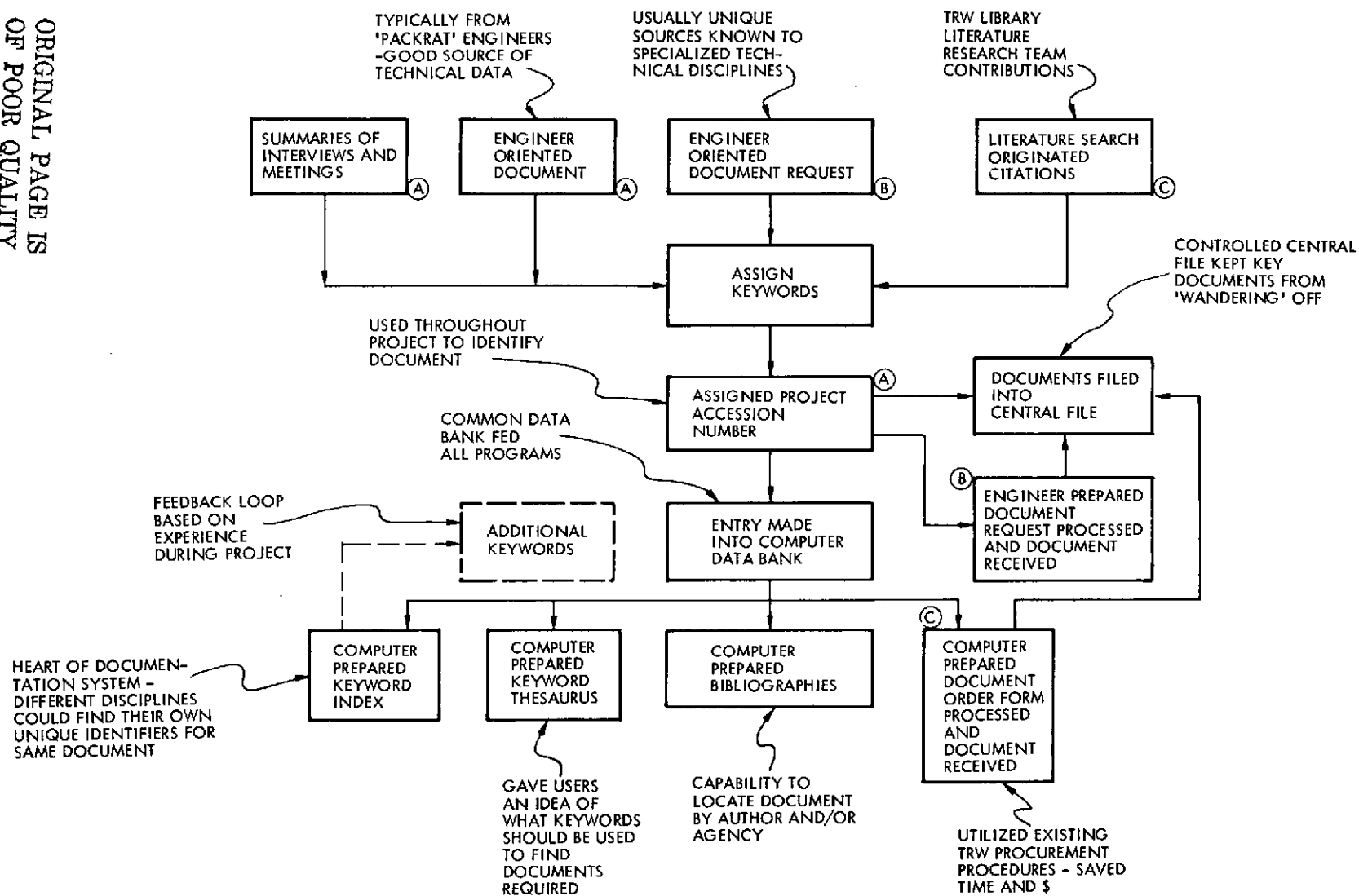


Figure 2-1. Document Control System Used on Technology Assessment of Portable Energy Project

file by author, keyword/subject category, or originating agency/corporation. For example, if information on methanol is required, simply looking under the keyword "methanol" will result in obtaining the location of all documents (by accession number) containing information on methanol.

Because of the inherently low cost of preparing computer listings, several updates of the indexes were processed and made available to project personnel. The updated index listing of 20 August 1974 was processed directly on reproduction mats and working draft copies were prepared for the Monterey Workshop of August 25-30. A final index listing will be prepared at the conclusion of the project and submitted to NASA Ames Research Center as a separate report. Further detailed descriptions and instructions on the use of the indexes will be included in the separate report.

2.1.2 Hardcopy Document File

The documentation amassed during the project was collected in a central repository. Each document was filed sequentially based on the project accession number. The file through 15 August 1964 was duplicated and brought to the Monterey Workshop by TRW in accordance with the direction of the NASA Project Monitor. This duplicate file was forwarded to The University of Texas after the conclusion of the workshop. Documentation amassed since the workshop will be duplicated and forwarded to NASA Ames Research Center at the conclusion of the contract.

2.2 PREPARATION AND OPERATION OF WORKSHOP

2.2.1 Workshop Objective

The objective of the workshop was to assess the portable energy technology and the social impact of this technology in the 1980's and 1990's. Because of the potential interchangeability between different forms of energy, it was immediately evident that the portable energy problem could not be treated independent of the total energy situation. Consequently, the workshop really addressed the overall energy situation in the 1980-2000 time frame.

The workshop was designed as a forum for collecting and documenting a broad, comprehensive spectrum of attitudes and opinions regarding these specific topics:

- The most promising approaches or means of providing adequate supplies of (portable) energy
- The critical issues, e.g., the social, environmental and institutional impacts, associated with these approaches
- The near-term actions required to implement these approaches.

In dealing with these topics, the intention was to obtain a balance between technical and social concerns. The purpose was to achieve a consensus on approaches, issues and actions, to clearly identify valid differences of opinion.

An implicit, but real objective of the workshop was to conduct an "experiment" on the use of behavioral science methodology in the operation of this kind of workshop — the assessment of both technology and the related social impacts.

2.2.2 Workshop Approach

A group of competent people, representing a diverse cross section of technical and social disciplines, was assembled; the group members were asked to state their positions on the topics noted above. The approach was personal — the participants were encouraged to speak for themselves as individuals, as well as for the groups they represented, and to interact with each other directly in exploring alternate approaches, critical issues and recommended near-term actions. In other words, meaningful dialog was initiated between people with different orientations.

The basic assumption was that with the right participants — people who themselves have relevant information of the problem — the task in running the workshop was to get them to express and share their opinions as fully and openly as possible. It was expected that this approach would not only lead to greater clarity and understanding of differing viewpoints, but would also provide the basis for a meaningful consensus.

Background information for the workshop was provided in the form of six scenarios, some two dozen potential actions, i.e., possible alternatives or means of supplying portable fuels, and a data bank of documents related to the energy situation. Unfortunately, the background data were not effectively utilized in the workshop, partly because of the basic workshop methodology, and partly because the participants, collectively,

already possessed much of the data. An alternate methodology would have been to employ an analytic approach involving planning against the scenarios. It was decided, however, to focus directly on the stated workshop objectives of identifying and synthesizing individual viewpoints on approaches, issues, and near-term actions.

To facilitate effective expression of individual viewpoints, the workshop was organized into small work groups of eight to ten people. Each work group included a chairperson and a group process facilitator, and the task was to deal directly with the stated workshop objectives. The work groups met in a relatively unstructured and informal environment, both in terms of physical arrangements and in terms of detailed agenda or method of approaching the task. The rationale was that small groups in an unstructured environment provides more discussion time for the participants and permits the development of a higher level of mutual trust, thereby increasing both the quantity and quality of personal expression and interpersonal communication.

In order to integrate the results from each work group, periodic reports of the discussion results were made to the total workshop. This feedback was in two forms; written reports distributed to all participants and verbal reports by the group chairpersons in meetings of all workshop participants. The workshop also provided for informal cross-communication between work groups during scheduled free time.

Preparation of the written reports was facilitated in several ways:

- The group chairperson was made explicitly responsible for producing this documentation, and this was his or her primary function.
- A time schedule was established for producing an interim report and a first draft in each series of work group sessions.
- Secretarial support and a Xerox machine were provided in the workshop control room.

The written reports provided feedback between work groups and also served as in-process documentation of the workshop.

An additional element of the workshop design was the use of two sets of small groups, A and B groups. The A groups met first and were

homogeneous with respect to the participant's professional discipline and orientation. These work groups met for approximately 1 day and then reported to the entire workshop. The B groups, conversely, were heterogeneous with respect to professional discipline. The result was that each participant worked first with people of similar orientations and then with people of different orientations.

The rationale behind the A and B structuring was to clearly identify and differentiate viewpoints of each discipline or interest area; then the interests were mixed to explore the nature of the differences, identify similarities, and develop a cross-discipline consensus. The two sets of groups also provided an opportunity for participants to interact with more people and insured that cross-discipline differences of opinion were addressed.

Initially the same chairpersons were retained for both A and B work groups. When the B groups met, it was apparent that the six chairpersons had a large burden and arrangements were made for other participants to share the responsibility. For five groups the same chairperson was retained for the entire workshop; having the same chairperson maintained a sense of continuity through the A and B groups and may have been the best approach.

Luncheon speakers were selected to provide an input to the workshop on current U. S. energy policies as seen by higher levels of Government. In this respect, they provided useful data. Unfortunately, time for an adequate interchange between the speakers and the participants was not possible and consequently, their contributions were not well integrated into the workshop process.

In running the workshop, a special effort was made to continually focus attention on the objectives of the conference; the process for reaching the objectives was not specified. The objectives were delineated in the prework material, stated in the general sessions, and restated in the work groups. (At the end of the workshop, several participants still did not know what the purpose of the workshop was!)

A consensus from participants with often opposing viewpoints was gained by using the concept of "differentiation and integration". This

concept deals with the process of change, in this case changing from disagreement, argument, and adversary positions to mutual understanding and joint support for common goals.

The first step is to achieve a full, complete, honest expression of the extreme differences between the two parties — in fact, to increase the polarity of the situation. The natural laws of human interaction seem to be that once each person's position is fully expressed and each party feels he has been fully heard, spontaneous change then occurs in the direction of integration, acceptance, and consensus on some common position that could not be seen or even predicted at the outset. The predictable aspect of this process is the change and the tendency toward integration around some common position.

It was assumed that differences of opinion are valuable and, in fact, that conflict is valuable, in terms of promoting creative problem solving. Another way of mechanizing the differentiation/integration process was the use of homogeneous A groups and heterogeneous B groups.

In addition to the specific results of the workshop described in the following sections of this report, several concomitant benefits became apparent. First, it was clear in both the content and the emotional tone of the second general session that a significant degree of mutual understanding, respect, acceptance, and agreement had taken place. Second, a very real spirit of dedication and individual commitment was indicated by many people working well beyond the scheduled time. Finally, in the written critiques of the workshop, a number of specific statements appeared that indicated a general feeling of enlightenment, clarification, and movement toward common ground. In terms of achieving a balance between technological and social interests, the critiques indicated a new awareness of technical issues by nontechnologists and social issues by technologists.

One of the by-products of the workshop, perhaps equally as valuable as the documentation itself, was the initiation of a new kind of relationship between people. One person said the workshop 'provided a 'fabric' for communication and dialog between extreme positions.' A number of people believed they obtained something valuable for themselves in terms of new information, new insights, and new contacts with competent and concerned human beings.

2.2.3 Workshop Participants

The selection of participants was a key part of the workshop. The basic criterion was to achieve a balance and competent representation across a broad spectrum of disciplines and viewpoints. In the sense of competence, people were chosen who were:

- Respected leaders in their fields
- Articulate and able to communicate
- Intelligent and informed about the issues
- Concerned for public interests
- Interested enough to spend a week working on the problem.

In terms of disciplines and orientations, candidate representatives were selected from:

- Each major executive agency of the Federal Government
- The Federal Legislature
- Energy technologists — producers, research and development people, and energy users
- Economists and financiers
- Environmentalists and public advocates
- Sociologists and political scientists
- The news media

The process of selecting and identifying candidates was a joint effort by the NASA, TRW and University of Texas teams. NASA-Ames played a major role in the selection and also in the actual process of inviting and encouraging participants to attend. Several hundred people were considered; about 100 were invited; approximately 40 accepted and attended.

In retrospect, the balance between the various disciplines and viewpoints was not as good as desired. Representation of the news media and of working politicians and legislators was inadequate although most of the participants were quite cognizant of the political process. Also, the desirability of including members of the younger generation as working participants was overlooked.

2.2.4 Workshop Schedule

The detailed workshop schedule (Table 2-1) provided set times for each activity — small work groups, report preparation, typing and reproduction, general sessions, free time, programmed lunches and special events. This predetermined schedule was followed almost exactly; the only exceptions were the rescheduling of some staff meetings, a 45-minute extension of the last general session on Thursday, and the addition of a press conference on Friday. The times shown in Table 2-1 were the actual times for the workshop; however, several groups worked beyond the scheduled quitting time.

The schedule provided a total of 8 hours for the A work groups, 11 hours for the B work groups, and 4-1/2 hours for the general reporting sessions. Two afternoons provided free time and two luncheons with speakers were arranged. It appeared that the schedule was reasonably optimal, within the basic 5-day time constraint.

Arrangements for hotel accommodations, meals, and other amenities were an integral part of the workshop planning and operation. Schedule lead time for the hotel necessitated precontract reservations which were made about 6 months before the workshop. Detailed coordination of these arrangements required the full-time involvement of one person. Arrangements for participants' spouses were intentionally handled informally. No program for wives was planned and no special recreation arrangements were made. Instead, the wives of some of the TRW staff contacted the other guests for informal get-together. The arrangement seemed to be quite satisfactory.

2.2.5 Recommendations for Future Workshops

One of the purposes of the workshop was to experiment with a different approach and structure for technology assessment conferences. Specifically, behavioral science methodology was assessed for its effectiveness in this kind of program. At this time, the experiment appears successful and some significant ways to improve the program were determined.

Table 2-1. Detailed Time Schedule

<u>Sunday</u>	3:00 - 6:00	Registration and Check-In
	4:00 - 5:00	Staff Meeting — Facilitators, Technical Representatives, and Workshop Leaders
	6:00 - 7:00	General Session - Terrace Room I Welcome — Bob Spraul and Al Worden Keynote Address - Hans Mark
	7:00 - 8:00	Reception — Terrace Room Patio
<u>Monday</u>	7:30 - 8:45	Staff Breakfast (Work Group Chairmen and Facilitators)
	9:00 - 9:30	General Session — Pebble Room Introduction and Overview — Lou Jensen Objectives of the Workshop Schedule and Methodology Work Group Assignments Constraints/Scenarios
	9:45 - 12:15	"A" Work Groups — Small Room as Assigned
	12:30 - 2:00	Host Lunch — Beach Room Address — Al Weinberg
	3:00 - 6:00	"A" Work Groups — Prepare Interim Status Report
	6:00 - 8:15	Free Time and Dinner (no host)
	6:00 - 8:30	Type and Repro Interim Reports and Distribute to Work Groups
	8:30 - 10:30	"A" Work Groups Summarize Results Prepare Draft of Final "A" Group Reports
	10:30 - 12:00	Type and Repro Drafts of Final Reports
<u>Tuesday</u>	9:00	Distribute Draft Reports to Work Groups
	9:00 - 10:15	"A" Work Groups Finalize Reports Critique Work Group Process

Table 2-1. Detailed Time Schedule (Cont.)

<u>Tuesday</u> (cont.)	9:30 - 12:00	Type and Repro Final "A" Group Reports and Distribute to all Participants
	10:30 - 12:15	General Session — Pebble Room Reports from "A" Work Group Chairmen "B" Work Group Assignments
	12:30 - 7:00	Lunch (no host) and Free Time for Participants
	2:00 - 4:00	"A" Work Group Chairmen edit/revise reports as required, retype, and repro
	7:00 - 8:15	Dinner (no host)
	8:30 - 10:00	"B" Work Groups
<u>Wednesday</u>	9:00 - 12:15	"B" Work Groups
	12:30 - 2:15	Host Lunch — Beach Room Address — Mike McCormack
	3:00 - 6:00	"B" Work Groups — Prepare Interim Status Report
	6:00 - 7:00	Staff Meeting
	6:00 - 8:30	Type and Repro Interim Reports and Distribute to Work Groups
	6:00 - 8:15	Free Time and Dinner (no host)
	8:30 - 10:30	"B" Work Groups Summarize Results Prepare Draft of Final "B" Group Reports
	10:30 - 12:00	Type and Repro Drafts of Final Reports
<u>Thursday</u>	9:00	Distribute Draft Reports to Work Groups
	9:00 - 10:15	"B" Work Groups Finalize Reports Critique Work Group Process
	9:30 - 12:00	Type and Repro Final "B" Group Reports and Distribute to All Participants
	10:30 - 1:00	General Session — Pebble Room Reports from "B" Work Group Chairman
	1:00 - 5:00	Lunch (no host) and Free Time for Participants

Table 2-1. Detailed Time Schedule (Cont.)

<u>Thursday</u> (cont.)	2:00 - 4:00	"B" Work Group Chairmen edit/revise reports as required
	3:00 - 4:00	Staff Meeting - Planning for Executive Summary Session
	5:00 - 9:00	Host Tour, Monterey Peninsula Reception and Dinner - Carmel
	10:00 - 12:00	Type and Repro "B" Work Group Report as required
<u>Friday</u>	9:00 - 11:00	General Session - Pebble Room Executive Summary Al Worden, Workshop Leaders, Group Chairmen
	11:00 - 12:00	Press Conference - Group Chairmen, Project Managers
	12:00	Adjournment

The first area of improvement required is a clearer, more specific, and more workable statement of the workshop objectives and better advance communications of these objectives to the participants. This would require more pre-workshop discussion at all levels and in-depth identification of what, exactly, is desired. The practicality of accomplishing the objectives in the time available should be thoroughly considered. The most valuable kind of data the participants can provide is their own attitudes, opinions and rationale; detailing, that could be better provided by a technical study team, should be eliminated. Essentially, the stated objectives should be realistic, useful and completely understood by all participants.

It is recommended that the work group chairpersons be more explicitly briefed on their roles and responsibilities and the methodology of the workshop. They should be involved in the first staff meeting, for example.

Greater effort should be expended on ensuring the right mix and attendance of the participants necessary to meet the workshop objectives.

A part of this issue concerns the guest speakers. There are two aspects to this problem: (1) having the right mix, and (2) the conference impact in terms of the message conveyed to the general public and the political community. In terms of the mix problem, representation from the legislative/political area, the news media, and the younger generation was lacking. In future studies, the participant group should definitely include some of the people who will be running the country in the time frame being studied.

A large part of the public image of the conference is determined by the story as published by the news media. Considerably more effort is needed to ensure that the true picture of the conference emerges. One of the key problems identified concerning the energy situation was that of accurately communicating the key issues to the public. One way to effectively communicate the workshop results to the public would be through news media participation. Another would be to recognize what aspects of the conference the media would be most sensitive to, e.g., the main speakers, and then to ensure that these channels of communication reflect the true conference meaning. A third mechanism is to give more attention to press conferences and press releases. The conference leader and participants should be directly involved in this process by perhaps writing the releases and constructing the press statements.

One important recommendation is to greatly condense and summarize any input data distributed to participants before the workshop. Experience showed that virtually no one read any of the prework before the workshop. Moreover, the material provided was far too detailed for the purpose intended, and little was done to properly summarize what was presented. As a guideline, not more than a dozen pages of information should be distributed preworkshop; this should be properly written and summarized for busy people to assimilate.

Beyond the prework information, other input data used in the workshop should be much better organized. Emphasis should be on facts rather than on speculations and opinions by people less competent than the participants themselves. It is suggested that some time in the workshop be devoted to "data briefings" by selected participants who are especially knowledgeable on the subject matter. If written data are provided, time should be allotted in the workshop for reading and studying the material.

In terms of secretarial support and the control room operation, an important factor is the cooperation, commitment, and flexibility of the staff. Four secretaries were adequate for the size of this job. This allowed for a two-on and two-off shift arrangement during normal hours with all four present to handle peak loads. Recommendations from the four secretaries are as follows:

1. Better isolation and access control for the secretarial support area. Much confusion occurred when participants chose to socialize in the control room.
2. Better coordination of input and output to the secretarial area. One of the secretaries should be designated as coordinator with the following responsibilities:
 - Taking requests for typing and dictation
 - Informing requestors of the time required to complete the job
 - Proofing typed material and Xeroxing the required copies
 - Making the completed job available to requestor
 - Answering phones and taking messages during peak periods.
3. A Xerox machine with two-side printing and collating capabilities would be very desirable.

2.3 WORKSHOP RESULTS, CONCLUSIONS AND RECOMMENDATIONS

These reports represent the principal formal product of the deliberations of the workshop participant groups. They are presented here essentially as they were prepared at the workshop. Editorial intrusion has been limited to the correction of typographical errors and to the clarification of some ambiguities in the texts that arose because of the severe time constraints under which they were produced. Minority opinions and reports are also presented along with the formal group reports.

GROUP A1

ECONOMIC EXPANSION AND INDUSTRIAL GROWTH

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Orson Anderson

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SCENARIO #1

The general theme characterizing the United States in this portrayal of the future is economic expansion. A general consensus existed in the society supporting economic expansion and industrial growth. Although the society was heavily oriented toward a service economy, "privatism" characterized the economic structure. The supply and consumption of energy were virtually unconstrained.

ENERGY CONSUMPTION

1985: 129.5×10^{15} Btu/year

1995: 195.0×10^{15} Btu/year

GROUP A-1

ECONOMIC EXPANSION AND INDUSTRIAL GROWTH

The scenario addressed by this group envisioned a future in which total energy demands were markedly increased by both an increase in population and continuing advances in the material standard of living in this country. While at first glance this future would appear attractive, a closer analysis of the implications of this scenario indicated that meeting these demands would require not only a maximum effort to increase domestic production but also a marked increase in energy importation, primarily in the form of oil and natural gas. The effects of the dramatic increase in domestic production required to meet these demands might well cause social dislocations and government intervention, while the increase in import requirements might result in balance of payment problems and international tensions.

The scenario as presented was taken as an indication of projected demands to 1995 and an attempt was made to match these demands against potential supplies, both domestic and foreign, by considering available energy sources. Disregarding economic and social limitations, the given scenario cannot be rejected outright: full development of all conceivable energy sources may yield the required 129.5×10^{15} Btu by 1985 and, with somewhat greater likelihood, 195×10^{15} Btu by 1995. The participants were, however, uncomfortable with the social and economic costs that must be paid to reach the specified goals.

Also considered was another, somewhat similar supply and demand case because a detailed portfolio was available of estimates for supply categories and costs in a scenario which specifies a U.S. energy availability of 97×10^{15} Btu by 1985. On the basis of a discussion of the details of this lower supply case, a number of stresses, were identified which would be greatly exaggerated for the significantly higher supply required for the given workshop scenario. These stresses included:

- Ability of the current financial establishment to handle the capital requirements. These financial demands are several times the current level of reinvestment to acquire and develop new energy sources such as oil, coal, gas and uranium.

- The financial investment requirement will be between a large (5%) to an intolerable (15%) fraction of the GNP.
- Acquiring and training of a major labor force for new and expanded resource development.
- A major strain upon the engineering and scientific communities to attempt this substantial labor force expansion.
- Major relocations of people to sparsely populated areas of Colorado, Wyoming, Montana, Utah and other new energy producing areas.
- The possible direction of oil and gas resources toward selective end-use markets.
- A politically sensitive water resource reallocation to satisfy energy resource and conversion facility developments. This will be particularly acute in the Colorado River Basin and in the northwestern coal fields.
- A crash program to expand fuel and energy transportation systems, particularly railroads, pipelines, and electrical transmission lines.
- Large foreign-trade deficits on energy fuels, even if as little as 15% of the energy is imported.
- In case of foreign energy supply limitations, competition for these supplies may lead to political problems with other resource-deficient countries.

The impact of a crash R&D program on this energy scenario was not properly evaluated, but clearly merits consideration. In general, it was felt that development of technology for utilization of various energy resources, including coal, shale, solar, etc., is very important to relieve demands on the domestic supply and that concerted efforts should be made in that direction immediately. However, it was noted that traditionally a long lead time is required until the industrial base is built for such new technologies. To facilitate such implementations in the future, new legal, managerial, and institutional structures/interfaces may have to be created.

GROUP A2

ENVIRONMENTAL CONCERN AND ECOLOGICAL PLANNING

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Ida R. Hoos

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SCENARIO #2

The general theme characterizing the United States in this portrayal of the future is represented by increased environmental concern and ecological planning. A general consensus existed in the society supporting a national environmental policy. Further, this solidarity directly affected other social institutions, such as the economy. The consumption and production of energy were significantly constrained in comparison to those levels characterizing the 1960's and 1970's.

ENERGY CONSUMPTION

1985: 112.7×10^{15} Btu/year

1995: 147.5×10^{15} Btu/year

GROUP A-2

ENVIRONMENTAL CONCERN AND ECOLOGICAL PLANNING

Introduction

Planning for the decade of the Eighties carries implicitly a plan for the Nineties as well. Thus, if we expect or desire a particular future twenty years hence, the strategies undertaken for the short-term must be either expendable or, better, in harmony with that future. Group Two has a relatively easy task from a technological and resource point of view because energy demand is positioned to rise slowly. But the social problems of achieving the scenario are difficult since it ultimately calls upon public perceptions and actions to change. Human beings are conservative and the required changes have long lead times. Therefore, the basic message drawn from the group deliberation is that planning must be done now for low growth in the Nineties.

We considered the modest augmentation of supply which will be required to reach 113 Q by 1985. Unfortunately, the most environmentally acceptable means of energy production are the least likely to produce large amounts of energy by that time; conversely, the most productive methods have the worst environmental insults associated with them. Nonetheless, we urge early, heavy financing of private and public research and development of clean energy sources (solar, wind, geothermal, etc.) even though 1985 pay-off is low. We believe that this research will free us from heavy continued dependence on the more polluting forms of production (coal-based strategies or nuclear energy) during the following decade.

Section I: Achieving the Scenario

A. Reaching 113 Q by 1985

Supply

The following table suggests the number of Q's of additional production over the 1974 production (75 Q) which could be achieved by various strategies.

Use Solid Waste for Energy Production

Low estimate: Conversion of 60-70%
of the industrial, agricultural and
residential wastes currently collected. 2 Q

High estimate: Conversion of 60-70%
of all solid wastes including agri-
cultural, forest, and other such wastes
not currently collected. 7 Q

Enhanced Oil Production

Outer Continental Shelf 2 Q

Alaskan Oil 4 Q

Nuclear 20 Q

Increased Oil Imports 0 to 5+ Q

Solar and Geothermal 1 to 2 Q

Coal (associated with massive land
reclamation, water and legal
problems) 15 Q

Natural gas* 0 Q

Total Additional Q's 51 to 57+ Q

This table illustrates that it is possible to supply 113 Q (or more by 1985 if the immense capital can be generated. As a measure of the capital requirements, the NPC** has estimated a total cost of \$600 billion to increase production to 129 Q by 1985; the cost curve is not linear, but the cost is at least double current capital investment (\$18 billion/year).

Demand

The NPC growth curve predicts a 1985 energy demand of 129 Q. To achieve the needed savings of 16 Q ($129 - 113 = 16$ Q), we must concurrently undertake a series of conservation actions:

*Even zero growth of natural gas production will require a major capital investment to maintain 1975 levels.

**National Petroleum Council.

- | | |
|--|--------------------|
| 1. Increase the average miles per gallon of the automobile fleet from the 1973 figure of 13 mpg to 26 mpg. * | 5 Q's saved |
| 2. Residential and commercial conservation (insulation, heat pumps, lower lighting and heating standards, etc.). | 8 Q's saved |
| 3. Industrial (more efficient processes, new processes, technologies, etc.). | <u>4 Q's saved</u> |
| B. Reaching 138 Q by 1995 | 17 Q's saved |

1. Basic Assumption

2%/year growth in energy use per capita, or an increase of about 25 Q from the "base level" of 113 Q attained in 1985.

2. Supply ΔQ : 1985- 1995

Oil (OCS)**	6
Solar/Thermal and Geothermal	5-10
Coal	7
Oil Shale (in situ)	<u>2-4</u>
	20-27 Q

Thus, it is technically possible to satisfy a level of U.S. energy consumption of about 138 Q by 1995 without increasing nuclear electric power generation above the 1985 level; provided, however, that the necessary steps are taken in the decade 1975-1985 to prepare the way for a large-scale utilization of solar/thermal and geothermal energy sources.

Section II. Evaluating the Strategies

Some of the strategies which have been suggested for achieving the scenario are viewed with favor by the group. They include:

- 1) Conservation
- 2) Improved efficiency of use

*This would require, given present technology, a relaxation of the nitrogen oxide standards contained in the Clean Air Act Amendments from 0.4 grams per mile to 2.0 grams per mile. This violates our given scenario.

**Outer Continental Shelf.

- 3) Energy from solid waste and recycling
- 4) Solar energy
- 5) Geothermal energy
- 6) Exotic energy forms (wind, thermal gradients, biological, etc.)

On the other hand, there was concern about:

- 1) Nuclear
 - Waste disposal
 - Safety of operations
 - Vulnerability to terrorists
 - Diversion of nuclear materials
- 2) Coal
 - Oxides of sulfur in gases
 - Residuals from sulfur oxide removal
 - Mining techniques
- 3) Increase domestic oil production
 - Spills (tanker traffic)
 - Low level leakage
- 4) Multinational Corporations
 - Divided loyalties

Because conservation is viewed by our group to be uniquely suitable for an environmentally conscious world, we attempted to examine some of the positive and negative aspects of that strategy, as well as some of the near-term actions which would assist bringing it about.

Positive benefits and supporting groups:

- Conservation of the "leak-stopping" variety is good business since it cuts costs.
- Retrofitting and rebuilding will create economic opportunities for both labor and capital.

- Conservation provides a means of "earning" energy which has virtually no residual effects; in particular, it provides an extremely attractive alternative when compared with a nuclear future.
- Supporting groups include conservation organizations, certain business, affluent, educated public.

Negative factors and blocking groups:

- Inertia and drag caused by existing large capital investments in older technologies.
- Fear of work mix dislocations such as shorter work weeks.
- Fear by interests which faced short-term harm, such as certain unions and certain businesses.
- Blocking groups include those groups which fear short-term harm and a number of large government agencies which have a stake in continued growth of certain technologies.

Near term actions which would help to meet goal:

- Deregulation of natural gas prices.
- Full cost pricing of all energy forms
- Government subsidy for emerging conserving technologies.
- Broad scale private and public efforts to change the ethic concerning energy and material use; public information and public education.

Similarly, on the supply side, solar energy was viewed to be the most promising technology for large-scale support.

Positive benefits:

- Non-polluting energy source.
- The developed technology may be exported as foreign aid, for balance of payments or to prevent the spread of nuclear technology to less stable governments.
- Allows local or district energy production, adding to system reliability.

Negative factors:

- High initial cost.
- No solar-electrical technology now exists at economic costs.

- No solar-cooling technology now exists at economic costs.
- Building trades and lenders are conservative, obstructing change.

Section III. A Special Word About Nuclear Energy

Nuclear power attracted particular concern. The problems associated with nuclear power generation are great. Even though nuclear technology seemed to be the most readily achievable source of power, this advantage was offset by the many negative aspects. It was urged that one strategy which could be followed would be to rise up to no more than 20 Q of nuclear power by 1985 (and less if oil imports or strong conservation measures could be imposed) while solar, geothermal and other clean technologies were heavily supported. Then, new nuclear plants beyond 1985 might not be necessary, and existing plants could be phased out at the end of their economic lives.

Almost half of the group felt so strongly about nuclear power that they called for a moratorium on all further construction of nuclear fission plants substituting stronger conservation measures and reliance on oil imports and coal. This group sees plants as unsafe, unnecessary, and unreliable. Major safety problems having to do with waste, fuel reprocessing, sabotage, terrorism, and competent management are basically insolvable due to the nature of human beings. Therefore, this group recommends the phasing out of all nuclear plants which at the present time produce only a very small part of the nation's energy needs. These needs can be covered by immediate implementation of conservation plans to cover both consumer and industrial processes, and the use of oil, gas, coal, and limited use of solar and geothermal energy. There are many examples of problems inherent in the unreliable performance of nuclear plants. There are many plants that have been shut down for long periods, and the long term requirements and costs of repair to such plants have been recognized as serious problems by utilities experts. The nation has yet to recoup from these plants the amount of energy used to develop them.

This part of the groups does not support the position that reliance on nuclear power plants should continue in the short term or until other alternatives become available, and for good psychological and sociological

reasons. Cultural change in the United States is more likely to come about through stress, as illustrated by last winter's energy crunch. Only by removing the reliance on nuclear, by completely phasing out the present plants can we phase in solar, geothermal, or anything else. Phasing out nuclear provides higher priority and incentive for exploring alternatives which to date have not been sufficiently explored because nuclear plants have been, wrongly in our judgment, presented as a panacea for energy needs.

The economic system that would accompany such plans would be a no waste (not no growth) 2% a year growth that emphasizes growth in quality, not in trinkets, that would redirect the construction industry from building office buildings to building homes to meet the shortage, that would redirect banks from investments in multinational corporations to funneling them back into the poorer sectors, that would encourage growth in services in the health and cultural areas. Project Independence would be seen in the full. Multinational corporations would be reevaluated as to their divided loyalties and as beyond the reach of every nation's law. The reality of having to buy uranium from other countries to meet the needs of nuclear plants would lead us to reevaluate our position vis a vis oil.

Section IV: A Special Work about Multinational Corporations

The role of the multinational corporation in the world of transportation and energy supply/consumption will be far from clear in 1985. In 1975, the largest 15 multinationals had gross "national" products that were larger than all except the 15 largest nations. General Motors had a "GNP" larger than Belgium and several major countries in South America. Their production and social influence is often on a par with governments. Multinational Corporations are legal entities beyond the legal reach of any single government or of any existing world government. They are non-representative superorganizations which will have a significant impact on global energy management.

Two possible roles for the growing number of multinational corporations will likely be clearer in the late 1980's.

In the positive role they could provide an efficient mechanism for management of global energy and global resources. Without the traditional inertia of government bureaucracy, they could provide the global networks for information-interactions which no world government will be in the position to match in this century. Enlightened management of MNC's could adopt the current motto of China -- TO SERVE THE PEOPLE; as a necessary alternative to a purely profit motive.

The negative aspects of multinational corporations lay in the dangers seen by a growing number of those who have lost faith and confidence in SUPER ORGANIZATIONS and are suspicious of the evil in MNC's. In the negative aspect some MNC's could be turning the planet into a company store by 1985 with over two billion employees-consumers who are totally dependent upon the legally untouchable MNC's for their livelihood and very existence.

Section V: An Alternative Future for 1995

To promote the notion of Zero Energy Growth (ZEG) is merely to apply to the consumption and production of energy the same brake on exponentiality that has been applied with some success to population growth and which is gaining support in this country and abroad. Implicit in the idea of ZEG is the recognition that energy is not an isolated, self-contained entity. To treat it as such, and to utilize only criteria of technical or even economic feasibility is to ignore and perhaps violate other important desiderata. What is at stake and must be taken into account is the total social environment; for this, the ZEG policy provides a course of rational action. The possibility or desirability of achieving ZEG was not shared by all members of the group, for these members not convinced by a ZEG world, a 2% growth rate appears more believable.

GROUP A3

INCREASED GOVERNMENTAL PLANNING

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Mike Korenich TRW FACILITATOR

Neal Richardson TRW TECHNICAL SUPPORT

Jerry Winter NASA TECHNICAL SUPPORT

SCENARIO #3

The portrayal of the future United States represented in this scenario is one characterized by increased governmental planning. The major effort at all levels of government in this society was an expansion of programs to produce equality of educational and economic opportunity. As the goals of these efforts become realized, the demand for energy was increased. This effect owes to the positive relationship between socio-economic status and energy consumption.

ENERGY CONSUMPTION

1985: 107.7×10^{15} Btu/year

1995: 145.3×10^{15} Btu/year

GROUP A-3
INCREASED GOVERNMENTAL PLANNING

Agreed Action Items

ENERGY SELF-SUFFICIENCY IS A NATIONAL GOAL

1. Resource Recovery

- a. Self-sufficiency is to change from 20% energy imports (40% oil energy) now to 5 to 10% imports by 1990.
- b. Amend environmental protection law to allow more time for full implementation of clean air standards goal of aiding self-sufficiency.
 - + Balance payments
 - + International political stability
 - Energy costs
 - Environmental costs
 - + Provides jobs at low skills levels
- c. Recommend floor under the price of imported energy (constant dollars) to allow competitive domestic sources to be developed. Stable tariff for 25 years.
 - + Greater confidence throughout economy
 - Costs more if foreign prices of oil drop to pre-embargo levels
 - + Energy consuming nations
 - Oil producing nations
- d. EDRA* to be major participant in cost sharing to develop means for insuring that new technology goes from research to commercial status (cost sharing method).

End at commercial or scaleable size from demonstration plant.

 - + Accelerates technology transfer

*Energy Research and Development Agency.

- e. Assure adequate domestic uranium supplies and enrichment facilities and fuel cycle facilities for self-sufficiency.
- f. Deregulate wellhead price on new natural gas.
- g. Government should address problem of obtaining capital for significant increase in electricity, coal, nuclear capacity.
- h. Use eminent domain to obtain land for coal slurry pipelines.
- i. Recommend that national needs take precedence over states rights in energy matters.

2. Resource Use

- a. Priority uses for natural gas are, 1) petrochemical, 2) residential, 3) commercial, and 4) other -- government should establish priorities of supplies in this order.
- b. Autos manufactured in or imported to U.S. should achieve 20 mpg on highway cycle after 197X; relax NO_x to 2 gm/mi.
- c. Speed implementation of electrified mass transit systems in urban areas.
- d. Prevent institutional (e.g., regulatory agencies) interests from blocking efficient transportation.
- e. Government should impose standards for minimizing energy losses in commercial and residential buildings.
- f. Federal government should specify land and water use planning on state or regional basis to be more cognizant of the energy requirements.

3. Research and Development

- a. ERDA should lead development of electric car as goal. Encourage production of special purpose urban vehicle.
- b. Accelerate R&D on nuclear waste disposal.
- c. Accelerate R&D on SO₂ removal (sulfur removal).
- d. Federal energy R&D policy should take heed of regionally specific opportunities.

- 4. Recommend FEA/ERDA to be combined into Department of Natural Resources that is headed by cabinet level secretary to plan for short and long range problems (constraints in manpower, materials, etc.) and to provide some priority for the necessary R&D.

- + World stability
- + Dollar stronger
- + U.S. regains former strength

GROUP A4

TECNOLOGICAL ADVANCES

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Myron Miller

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SCENARIO #4

Technological domination and advances characterize this portrayal of the future United States. In a sense this scenario represents most optimistic representation of the future society. Technological advances were impacting all the social institutions, especially the economy. The efficient production of goods and services were high. The production of energy was more efficient than in the past, and the demand for energy was virtually congruent with the supply.

ENERGY CONSUMPTION

1985: 112.1×10^{15} Btu/year

1995: 151.9×10^{15} Btu/year

GROUP A-4

TECHNOLOGICAL ADVANCES

Scenario

The workshop group A-4 decided that the Technological Advances scenario was deficient in these respects:

1. No recognition was taken of, nor data provided on the world situation, which may, in fact, be controlling.
2. The 1985-1995 time period was too near term for long-range solutions.
3. The 7-8% unemployment rate would lead to significant political changes. Privatization of citizenry would be inconsistent with the likely political changes.
4. The necessary 5% average growth in real GNP for Scenario 4 probably could not be achieved; since we are now in a zero growth period, a higher rate of 6-8% would have to be achieved in some sustained period; this would be phenomenal.
5. The possibility of climatological change affecting temperature and food production was not included.
6. An additional constraint set was necessary to evaluate the action options.

The first and last deficiencies were remedied by the group by the adoption of an overlay of moderate Project Independence requirements: Specifically, that the domestic crude production and that import crude remained at their respective 1971 levels of 20.5 Q and 11.8 Q.

Group A-4 determined the most promising approaches by a matrix analysis on "Technical Possibility", "Addition to Assured Reservoir" and "Cost" on a weighting scale of 1 to 3, 1 being good and 3 being poor.

Priority Matrix

	<u>Technical Possibility</u>	<u>Addition to Assured Reservoir</u>	<u>Cost</u>	<u>Total</u>
Synthetic Fuels	2	1	3	6
Redistributed Energy	2	2	1	5
Conservation/Efficiency	1	3	1	5
More Domestic	1	1	2	4
New Domestic	3	1	3	7
Imports	1	3	2	6

From this priority matrix, it is seen that more domestic energy from conventional sources is first in promise. In the 1985 period, this would be with emphasis on oil and gas production and in the 1995 period on coal and nuclear.

Conservation, although having a good matrix score, was not considered to be a major factor in balancing the energy supply and demand requirements because of its small effect on the assured reservoir.

Next in promise would be the synthetic fuel option with redistribution of energy as a subset following on the availability of synthetic fuels. In synthetic fuels, the possibility of liquid hydrogen was determined to be beyond the 1995 time period. This was determined because of the massive infrastructure required in the logistics of the distribution and supply system.

New domestic sources were given the lowest priority due to technological questions and cost. Imports were put last because of the lack of assured supply.

In the exploitation of domestic reserves, these positive and negative factors were noted:

Oil and Gas 1985

Positive

Known technologies
Widest applicability
Buys time
Only way to go

Negative

Diminishing reserves
Environmental problems

Coal 1995

Positive

Large reservoirs

Negative

Environment
Reclamation
Transportation

Nuclear 1995

Positive

Large reservoirs

Negative

Environment

Safety

Disposal of radioactive wastes

Security of nuclear materials

In the pursuit of the synthetic fuels option, these positive and negative factors were noted:

Synthetic Fuels 1995

Positive

Plentiful supply via
domestic coal

Use existing logistic
and engine infrastructure

Negative

Cost

Environment

Water requirements

Major plants are undemonstrated

Wasteful of coal Btu's

Sulfur and ash disposal

Necessary Actions

Since Scenario 4 presupposes a 1995 Transportation Sector Energy requirement of 34 Q and a petrochemical demand of 4 Q, = 38 Q total, with the presupposed supply of petroleum of 32.3 Q under the A-4 modified Project Independence described above, it is necessary to provide for the additional demand of 6 Q from synthetic fuels. This can be done for an investment of some thirty billion dollars, say forty billion, or approximately two billion dollars per year. This, it must be remembered, is just for synthetic fuels.

Group A-4 was of the opinion that the problems of raising the total dollars for financing the total energy picture of the future were so large as to far outweigh the considerations of particular strategies. The point is that such large sums however raised -- whether by direct taxation or by increased utility rates -- are a form of taxation and therefore require some form of representation in the decisions as to how and why they should be spent. The projected GNP growth (5%) will be necessary for achievements in this area without significant dislocations such as inflation.

In determining which steps should be taken for implementation of a Synthetics Fuel Plant, group A-4 suggests a pilot plant/systems approach. The systems approach is necessary to avoid being wasteful of coal-contained Btu's. That is, there is a coal availability/synthetic fuel supply/engine cycle consumption system which optimizes cost and energy efficiency.

When such a systems study indicates which synthetic processes should be pursued, pilot plants should be built before large full-scale plants to assure the validity of the technology, i. e. , to avoid the pitfalls of the nuclear breeder reactor program.

To carry out the full-scale demonstration system, the military sector offers these advantages:

1. The military sector can accept a noneconomic assignment.
2. The military sector provides a separate arena in which to test production and use.
3. The military sector can carry out a dedicated program more easily than in the civil sector.

Whereas the civil sector, the demonstration plant would be limited to the fuels in current use because of the requirement for minimum dislocation to the civil economy for such a demonstration test. The government could provide the financial incentive by providing the necessary level of price support to the producers.

GROUP A5

LARGE SCALE ECONOMIC RECESSION

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SCENARIO #5

The general theme characterizing this representation of the future United States is large scale economic recession. There existed in the early 1980's an inflationary spiral and a breakdown in the international monetary system. "Privatism" continued to characterize the economic structure although some restrictions were placed on the conduct of business. A number of public works projects, including environmental restoration, were initiated during this period to stimulate the economy. This task was all the more difficult owing to scarcities of energy and other resources, as well as significant international competition for them.

ENERGY CONSUMPTION

1985: 67.1×10^{15} Btu/year

1995: 103.0×10^{15} Btu/year

GROUP A-5
LARGE-SCALE ECONOMIC RECESSION

I. Scenario Development Status of the Economy - 1985

Data furnished to define the U.S. economy in 1985, as compared with actual 1970 figures, clearly represent a very major recession or a significant depression (negative GNP growth). Per capita energy consumption in 1985 is reported to be about 15% below 1970 experience, implying:

- A "no growth" economy, over the 10 year period, 1975/1985, coupled with conservation measures which also reduced energy consumption. It was recognized that many, particularly the young, might prefer "no growth" to continued high per capita Btu expenditures.
- A very significant "shock effect" due to the reversing of previous long-term growth patterns in energy consumption: these patterns have persisted through a previous long U.S. growth history under varying economic conditions.
- We asked "How did the U.S. economy find itself in this condition in 1985?" The group felt that the rapid application of high conservation measures and high energy costs caused the per capita drop. A lack of a strong governmental plan for increased supply, and thus a recharging of the economy for continued growth, resulted in the depression.

Such economies and conservation in the utilization of energy fuels (~16 Q or 8 MMB/D crude oil equivalent) can technically and culturally be accomplished, but there is doubt that this apparent no-growth trend, coupled with such economies of consumption as would reflect a net 15% reduction in per capita consumption, could occur without major adverse consequences to the economy (Table 1).

It would appear that the decline in per capita energy consumption over the period 1975-1985 is demand limited, not supply limited. Energy reduction measures have been adopted in all markets, not so much for reasons of the "conservation ethic" as for price. The Scenario demand of 67 Q is achievable with domestic supplies, but demand has not warranted the production effort to fully exclude imports. (Figure 1 portrays other countries, such as Sweden and Canada, with a high standard of living but with lower per capita energy consumption than the U.S.)

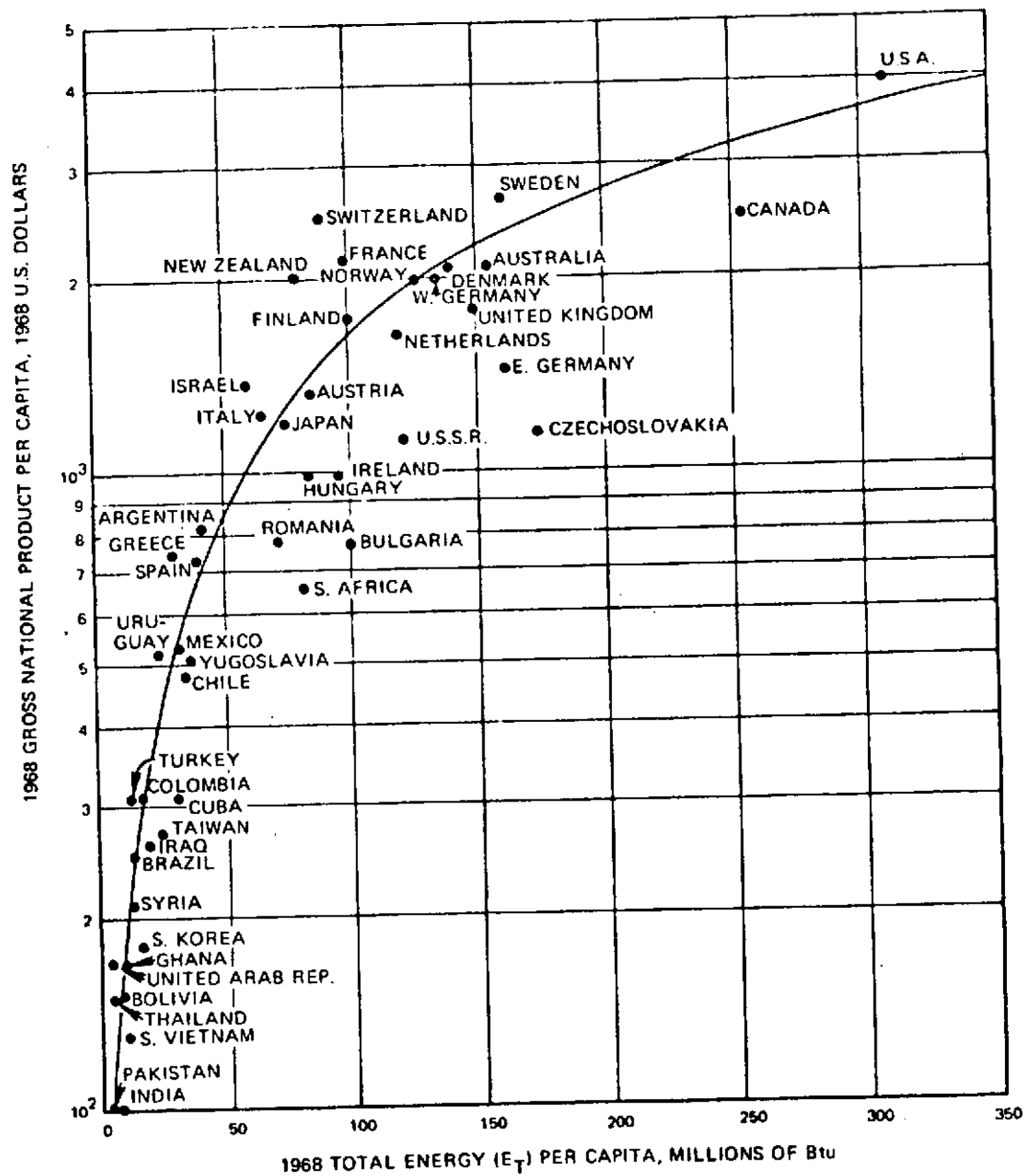
Table 1. Per Capita Energy Consumption
Scenario #5

Year	Population	Energy Consumption	Per Capita Btu Consumption
1950	151×10^6	34×10^{15} Btu/year	$.23 \times 10^9$ Btu/yr +50%
1970	203×10^6	69×10^{15} Btu/year	$.34 \times 10^9$ Btu/yr - 15%
1985	228×10^6	67×10^{15} Btu/year	$.29 \times 10^9$ Btu/yr +50%
1995	241×10^6	103×10^{15} Btu/year	$.42 \times 10^9$ Btu/yr

It is anticipated that the 1985 U. S. economy would be affected (or impacted) by this set of circumstances in ways which in part would parallel the 1929-1935 depression - for example, in the Great Depression of the '30's unemployment reached 25% and in our Scenario an unemployment level of 15% was experienced. But in other aspects the effects would be entirely different. For example, conventional Keynesian economic remedies such as deficit spending would only complicate the problem by adding to inflationary pressures, because energy fuel shortages would limit industrial production. We would expect, however, the following general effects to prevail:

- A return to more conservative economic policies, especially as to consumer spending and investment in capital items.
- Some significant return to isolationism in international affairs.
- Significant monetary deflation in the short run, and possibly long term, unless deficit spending is overdone.
- Minimum international trade as a result of the failure of international monetary policies.

We anticipate that widespread unrest causes the government to invoke regulative and legislative action to increase domestic energy supply -- in an effort to bring lower cost energy into the system and stimulate the economy. Resources are allocated to



Source: "The U. S. Energy Problem", Warrenton, Va., Nov. 1971, p. 26.

Figure 1. Gross National Product per Capita vs. Energy Consumption per Capita, 1968

facilitate energy industry expansion. Tax and loan guarantee incentives are devised. On the other hand, price controls are leveled at the energy industries to insure that return on capital, while attractive, will not be excessive.

While environmental controls on air and water quality are stoutly defended, temporary exceptions are granted to encourage rapid expansion of coal use. Coal gas, shale oil and nuclear expansion are encouraged. In the latter respect, siting laws require regional acceptance of nuclear power plants. The government increases the acreage let to bid for oil and gas exploration.

Laws are enacted to protect investors against major losses due to fluctuations in world oil prices.

Data provided for the 1995 economic conditions reflect a significant improvement over 1985, largely exemplified by reduction in unemployment from 15% to 8%, and a marked gain in per capita energy consumption. This latter gain is equivalent to a resumption of the historical long-term average annual growth rate of about 4% per year. We would anticipate that a part of the overall increase in energy fuel consumption reflects a "catch-up" situation over the latter part of the ten-year period. The fact that such growth in energy consumption could have occurred also reflects the successful results of the development of new sources of supply.

II. Status of Capital and Investment Markets within Scenario #5

A. Internal/Domestic

- Near panic exists in the money market.
- Capital becomes available only to low-risk basic industries.
- Restrictive government fiscal and monetary controls.
- Capital expenditures by private industry made only on a maintenance or replacement basis because new capacity not needed.
- Because of liquidity problems in the money markets, government financing is necessary to support private industry of national importance in an effort to seek real output gains for industries.

B. External/International

- Deterioration and near breakdown of the international monetary system.
- Government restrictions on imports and exports and control of foreign investment activities.
- International trade becomes raw materials oriented and large trade deficits result.
- Governments put emphasis on reducing trade deficits and balance of payments deficits and take "inward looking" attitudes.

III. Answers to Questions in Syllabus for Scenario #5

A. Most Promising Approach(s)

What do you believe are the most promising alternative approaches (potential actions) to insure adequate supplies of transportation energy in the 1980's and 1990's?

1. (In your view, what is an "adequate supply"?)

- An adequate supply of energy, as viewed from the midst of a severe depression would be considerably higher than the 67 Q specified as the consumption in 1985. The exact amount is somewhat indeterminate but, qualitatively, it would be described as sustaining a life style something like that of 1974 (but obtained without danger of foreign blackmail) and enhancing a recovery from the depression but, perhaps, restrained by U. S. commitments to the have-not populations of the world. Quantitatively, a value of 90 Q would probably be an adequate energy supply in 1985. An adequate supply for transportation energy would be about 25% of the total energy consumption, composed almost entirely of hydrocarbon fuels, although economic recovery might dictate a lower percentage for a few years.

2. (What specific approach(s) do you see as being most promising, who would be involved in implementing them, and what is the implementation time table?)

3. (What is the nature of the research and development required?)

4. (What other actions, e. g., legislative or administrative, are necessary?)

5. (What individuals or organizations should be responsible, i. e., have the lead, for implementation?)

- Development of the increased energy supply should, to the maximum extent possible, be carried out by private industry with private investment funds, but extensive government action will be required in this scenario. In a severe depression, private funds will be available only for low-risk, rapid return investment (which the energy expansion is not). Recommended government actions include:

R&D, through construction of full-scale demonstration plants, for coal and oil shale processing into portable fuels.

Incentives for private capital investment, such as:

- Changes in tax laws
 - Guaranteed loans
 - Guaranteed prices and markets - deregulated wellhead gas prices and a floor under oil prices.
 - Subsidies
 - Leadership in increasing productivity (e.g., reduced feather bedding)
 - Relaxed environmental restraints, reduced leasing red tape, etc.
- Energy expansion should be supported in a wide variety of areas. Primary emphasis in this scenario should be on relatively low-risk approaches, which include coal (with stack gas scrubbing), coal gasification, coal liquefaction, shale oil and nuclear (thermal). Some effort should also go into further-term approaches, such as solar (biological), solar (direct) and, perhaps, underground nuclear explosions (for in situ shale oil conversion). In some of the processes, notably coal gasification and liquefaction, there may be a need for government action to obtain priorities for plant equipment such as high-temperature, high-pressure vessels. A rapid rate of implementation, as recommended, may require such a government-enforced priority system
6. (What is the expected development cost and capital investment required?)
 - High -- probably higher than estimated in the Workshop source material.
 7. (What is the expected amount and unit cost of energy attainable?)

- The "adequate supply" proposed is attainable, but the cost per Btu will be high. Government action to reduce investment risk will permit a lower acceptable return on investment, thereby reducing energy unit cost relative to what it would be without government action.
8. (What is the expected impact on future aviation and inter-modal transportation research and technology?)
- The suggested approaches to increasing energy supply will result in a broad range of available fuels. No unique impact will be imposed on aviation or other transportation modes.

B. Advantages and Positive Factors of Recommended Solution for Scenario #5

The major advantages or positive factors in the recommended solution are:

1. Strong government action will unify the nation in the time of crisis.
2. The balanced program of Government taking the lead but through private industry channels as in Defense, Space, Mining, Agriculture, Transportation, etc., preserves the free enterprise system while at the same time meeting immediately critical demands and energy needs for the U.S. public interest. Thus, the strengths of free enterprise, competition, rapid response, timely introduction of innovation, efficiency, are preserved for future challenges.
3. The solution recommended is achievable. The increased use of coal and nuclear energy sources is an achievable goal to rapidly reclaim a desired standard of life. Proposed actions are technologically feasible within a relatively short period of time and without enormous risks.
4. Finally, they are targets which can be achieved with our own domestic sources, thus potentially implementing Project Independence even while enduring a harsh recession.

C. Adverse Aspects and Blocking Forces of Recommended Actions

Government leadership to increase productivity and minimize environmental constraints may result in:

1. Political - Labor unions will strongly resist government intervention in an area traditionally sensitive with most union leadership. Erection of coal based synthetic fuel plants will displace miners. This would probably delay

implementation of any proposed legislation in this area related to, say, synthetic fuels production. Productivity increases associated with energy conservation efforts would appear as a threat to the unions' leadership and perhaps their very existence.

2. Technical - Lack of heavy wall steel plate fabrication capacity (domestic and foreign) could slow any schedule for development of a synthetic fuels industry by 1995. Similarly, some steel alloying elements (e.g., chromium) could be in short supply. In addition, the U.S. is dependent upon importing some or all of these alloying elements. Embargos similar to the Arab Oil Embargo could severely hinder development of a synthetic fuels industry. Constraints would be largely in program schedule delays. Foreign suppliers of alloying elements and fabricators of plate could impede or stop deliveries to the U.S. for economic or political reasons.
3. Environmentalism - It is anticipated that national resistance will be encountered from environmental groups when any relaxation of pollution control standards (permanent and/or temporary) is proposed to implement or facilitate a buildup in energy production.
4. Regionalism - Local interests for parochial reasons will resist certain activities associated with increased energy production. For example, nuclear plant sitings will undoubtedly meet strong regional resistance as well as national environmental concern. Similarly, although Easterners may favor oil shale development, Colorado residents would strongly resist this particular approach to developing energy production.
5. Both environmentalism and regionalism would have a delaying effect on the overall program through prolonged political and legal actions.

D. Necessary Near- Term Actions

1. (What does it take to sell the approach to those who would support it?)
 - The American people have always responded to crises that they understood and wherein they saw an action plan which gave them the confidence of success. Then they were willing to sacrifice and do great things. The energy shortages and the consequent impact on our economy and our life style must be thoroughly explained, and everyone's involvement must be achieved. Methods for doing this will include TV, movies, textbooks, magazines and newspapers. However, it is tragic, and must be changed, that our public education system through High School

does not include the use of concepts of finite world use of irreplaceable resources and perhaps the use of models for trading off various energy policies. This use of models within the education system may be one of the best applications.

2. (What does it take to counter the opposition?)

- The opposition will be those who feel that the change will put them in jeopardy or who feel that their property or equity will be diminished equity will be diminished unfairly by the change. Examples might be union members who feel they will suffer from increased productivity or private investors in energy companies who feel that they have risked their capital, and the action of increased environmental controls or changes in plant processes to conserve energy will penalize their investment unfairly. Thus, to avoid opposition, we must have programs at public expense to pay for the dislocation or inequities and fairly deal with those who will be penalized for changes made in the national interest. We do have such laws for property condemnation acts to permit public works such as highways.

IV. Evaluation of the Workshop Effort, Recommendations, Conclusions, Etc.

A. Caveats -- The ability to model the stock market has failed because it is apparently a completely random process. The question was raised whether energy policy study with models could succeed because of its complexity. The group thought that one can model actions of industry and government (although not the stock market).

B. Sensitivities

- Data are not precise, qualitative only.
- Small changes on data may have extreme impact on output.
- Ultimate solutions are unpredictable so some effort on high-risk items is justified.

C. Resolutions of Issues -- How shall we resolve basic issues?

Good of nation vs. good of region -- handled by existing political process (legislative and judicial) -- provide full information.

D. Evaluation of Process

- Participant input to content of workshop in advance.
- Literature (bibliography) recommendation by participants in advance for general distribution.
- Lack of insight/articulation of why NASA is sponsoring (and why charge for personal follow-on action).
- Unclear as to NASA "charter" (in particular re-energy).
- Clearer use of scenario.
- Lack of information regarding 1974-1985.
- Not all participants received workshop book with enough lead time.
- Question use of scenario in A group -- perhaps only in B group.
- Limited time to deal with subject.
- Rating 1-10 compared to other workshops -- 6-7
- Technical and economic data base is same for all -- should vary dependent on scenario.

GROUP A6

INTERNATIONAL DISARRAY

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SCENARIO #6

The general theme characterizing this portrayal of future United States is international disarray. The economic and political policies discussed in this scenario resulted in the assumption by the United States of an increasingly isolationist stance in the 1980's and 1990's. The United States Middle East policy was an ambiguous one aimed at placating the Arabs and Israelis while pleasing neither. Accordingly the Arabs again utilized an oil boycott to influence world opinion with the result that the United States placed primary importance on the domestic development of energy. Diverse production strategies were employed by this country in an attempt to meet the demand for energy.

ENERGY CONSUMPTION

1985: 106.2×10^{15} Btu/year

1995: 139.3×10^{15} Btu/year

GROUP A-6

INTERNATIONAL DISARRAY

- I. Necessity for a mix of alternative potential actions because of social, economic, political and possibly technological forces.
- II. Impossible to agree on any particular mix.
 - Lack of comparative knowledge about alternative mixes, especially about risks and returns, even among technical experts.
 - Divergence of values, e. g., what degree of risk, what probability is acceptable, even assuming the probability were known. Should the opinions of immediately affected groups have more weight?
- III. Due to the divergence of values, the central issues appear to be political:
 - Need for dealing with political issues and political processes, e. g., how to increase rate at which regulatory agencies can deal with emergent issues?
 - Need to understand that current decisions by the U. S. and by other governments have long-range political consequences, particularly in the international sphere. Other countries are rapidly industrializing, and competition for scarce energy resources is likely to increase, even if U. S. imports of energy do not increase.
 - Need to define/understand structure of current political process, especially the role of special interests.
 - Need to encourage decision makers to deal with complex problems in complex ways. Specifically, how can you introduce new values into the political process? Mass transit, for example is an issue which seems to be technologically ideal, because (a) we have a range of possible solutions, (b) it's environmentally safe and acceptable, (c) it uses energy more efficiently, and (d) it is already on the political agenda. Yet, there is minimal federal aid for capitalizing mass transit and none for operating expenses. Hence, the problem is political.
- IV. Possible political strategies - or potential actions. Need for a mix, none would be successful alone.
 - (a) Better communication among the sources of knowledge, the public and the decision-makers.

- Objective, respected source to get facts to public.
- Appropriately chosen task forces can legitimize and publicize potential actions.
- Politicians need to listen to and interact with the public - the main mechanism for this is political action by the public (another potential action listed below).
- Continued interaction between the sources of knowledge and the public.

Obstacles:

- Evidence from social psychology strongly indicates that citizens pay attention to information only on those issues in which they are interested.
- Additional evidence indicates that most people selectively perceive and selectively retain only that new information which agrees with their preconceived beliefs and already held values.
- Evidence from political science indicates that politicians and lobbyists interact only when they already agree with each other.
- Decision makers are most likely to listen to those groups which can have a significant effect on their chances for elections or on their chances for a budget increase.

- (b) Social experimentation/demonstration and pilot projects, e. g. , research of effect on demand of efforts in Seattle and Atlanta to provide, respectively, free and reduced-fare bus service.

Obstacles:

- Who carries out the research? The administrator with vested interests or the objective researcher with no access or influence?
- How do you ensure that negative results won't kill the program?
- How do you interpret the results of experiments, e. g. , how generalizable?
- Need for better methodologies for design and analysis of social experimentation.
- How do you ensure that positive results will have an impact on future policy?

- (c) Political action. Will facilitate communication between public and decision-makers and can possibly make support of a policy politically necessary.

Obstacles:

- Now do you get citizens to actively support policies which have only a long-term or indirect impact on their personal lives?
- How do you get citizens to lobby actively for public goods, i. e., for those goods which, if provided to one individual are automatically provided to many individuals (national defense or cleaning up air pollution). In other words, how can you convince citizens to cease saying, "let George do it"? Similarly, how do you encourage the nation to consider the welfare of other nations in pursuing alternative policies?
- How do you get regulatory commissions, who typically define the industry they regulate as the client they serve, to develop a broader definition of their clientele?

- (d) Work actively with lobbies - even the opposition - to consciously construct a winning coalition.

One could design a mass transit package which satisfied very diverse but influential lobbies - namely the "PIGS" (public interest groups), i. e., NCL/USCM/NACO/ICMA/CSG/NGC (interest groups representing, respectively, cities, mayors, counties, city managers, governors, and state governments). For example, revenue sharing passed because all these supported it.

Need to provide benefits to multiple interests; need to remove FUD's (fears, uncertainties, and doubts).

Obstacles:

- The need to build a winning coalition necessitates compromise. This means, in turn, that the policy most likely to win is not equivalent to the most technological or economically optimal policy.
- (e) Need for presidential leadership and a dedicated, respected, popular advocate.

V. Summary

Energy policy is likely to be made even in the absence of sound, technical, economic and social information. For instance, failure to pursue a potential action is a decision which has long-range

consequences on the supply of and demand for energy. Decision makers, however, are constantly bombarded with information and demands. They cannot assimilate all of this information. Hence they are most likely to attend and act on that information and those demands which take account of their own needs. They are less likely to act on information and demands which reflect only the needs of a single group.

GROUP B1

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GROUP B-1

The Group B-1 addressed itself to assessing the subject objectives with specific emphasis on their application to aviation and intermodal transportation of the 1980's and 1990's. We examined:

1. The most promising approaches to insure adequate fuel supplies.
2. The positive aspects of each approach.
3. The negative aspects of each approach.
4. The near-term actions or first steps required.
5. Other aspects of potential important to the subject matter.

In Exhibit 1, an attempt was made to compare historical total USA energy consumption (1971) with projected total USA energy requirements for 1985 and 1995 assuming a very austere 2.3% growth rate to determine the shortfall. This resulted in a consumption of 75 Q's for 1971 growing to a projected 100 Q's for 1985 and 125 Q's for 1995. The transportation sector showed 18 Q's for 1971, 25 Q's for 1985, and 28 Q's for 1995. The growth in 1985 by 7 Q's and by 10 Q's in 1995 triggered the thought that this requirement might be provided by diverting petroleum from some non-transportation uses where substitution of other fuels is possible.

MAJOR ENERGY STRATEGIES

In order to provide for the demand projected in Exhibit 1, several major strategies have been proposed. The mix of strategies of major impact varies as a function of time since some conservation actions affecting demand can be taken almost immediately while other actions affecting supply, such as the production of synthetics, require substantial lead time especially in research and development. Strategies of major impact are listed in Exhibit 2 in approximate chronological order, with the exception of imports. We assume imports will be appreciable throughout the duration of the time period considered. Each strategy is discussed in more detail in the following paragraph.

EXHIBIT 1

HISTORICAL AND ESTIMATED PROJECTED
TOTAL ANNUAL ENERGY REQUIREMENTS FOR USA

	<u>1971</u>	<u>1985</u>	<u>1995</u>
Electric Power	19	28	43
Residential/Commercial	15	19	23
Industrial	23	28	31
Transportation	18	25	28
	<hr/>		
Total	75	100	125

EXHIBIT 2

MAJOR STRATEGIES

1. Conservation
2. Increase Production of Primary Energy
3. Synthetics
4. Imports

CONSERVATION

The panel assumed that there would be across-the-board attention to energy conservation, starting immediately. Because of the great number of potential conservation actions, we have only considered those actions we thought most important. These are discussed below.

Automotive Transportation

We believe that there are a number of state-of-the-art improvements that, if made by the automotive industry, will result in an increase in fuel economy of 25-50% for cars manufactured in 1985. These improvements include mandatory use of steel belted radial tires, reduced vehicle weight and engine displacement, better coupling of engine to drive wheels, and eventually more efficient, nonpolluting engines. The desirable long-range goal of shifting to electric propulsion was thought to be beyond the 1990 time frame.

Air Transportation

It appears that economies in air transportation are possible through improved load factors, improved scheduling, and elimination of short hauls.

Intermodal Transfer

We recommend an effort to shift transportation, especially freight, to more economic modes, i.e., air to truck or rail, and truck to rail. Along with this there should be a simultaneous effort to eliminate the institutional barriers that prevent the most direct and most economic modes to be used in all sections, e.g., more uniform state regulations.

A secondary benefit from upgrading our rail system for meeting material hauling will be high quality road beds better suited to high speed, intercity passenger trains.

Energy Conservation in Residential and Commercial Buildings

Conservation in this sector will permit some petroleum based fuels to be transferred to transportation. Thus the application of ideas such as improved insulation, low heat-loss structure design, and the use of total energy systems can relieve shortages in the transportation sector.

Distribution Systems Improvement

An appreciable energy savings could be made by improving the distribution systems. The need for reduced transmission losses will be greater in the future if nuclear reactors are cited in "parks", or when synthetic fuels are manufactured in large quantities from western coals.

INCREASED PRODUCTION OF PRIMARY ENERGY

Increased production of primary energy, coupled with increased conservation and foreign importation, provide the only immediate and near-term (through 1985) options in increasing energy supply. Among primary energy sources considered (Exhibit 3), immediate sources include: (1) increased production of oil and natural gas, involving primarily exploration and development of offshore deposits; more exotic secondary and tertiary recovery and advanced fracturing techniques will also increase production; (2) expansion of conventional nuclear capacity; and (3) extensive expansion of coal production. Some expansion of hydroelectric generation is possible, as well.

Important longer term sources (to be available by approximately 1995) include: breeder reactors, solar energy, and oil shale/tar sands. Each of these will require immediate substantial research and development investment.

It is clear that the increased production of near-term primary energy sources (oil, gas, coal, and conventional nuclear plants) pose problems in siting, safety, and security. Extensive coal mining, especially surface mining will meet with aesthetic objections even with reclamation legislation. In the more arid coal lands, water availability will be a significant constraint. Some relaxation of air standards will be necessary to increase coal use in the short term.

Synthetics

Although it appears that the demand for petroleum liquids for chemical feedstock and transportation might be met in 1985 by diverting most of the required liquids from other sectors, it is probable that ultimately natural gas liquids and petroleum will have to be augmented by synthetic liquids from coal. While it is our feeling that research and development

EXHIBIT 3

IMPACT BY 1985/1995, PROBLEMS AND PRIORITIES

	Coal		Oil		Cont. Gas		Nuclear		Solar		Shale	
	'85	'95	'85	'95	'85	'95	'85	'95	'85	'95	'85	'95
Research	H	L	L	M	L	M	L	L	H	H	H	L
Development	H	L	L	M	L	M	L	L	H	H	H	M
Prototype	H	L	L	M	L	M	L	L	H	H	H	L
Investment	H	H	H	H	H	H	H	L	M	M	H	M
Legislation	M	L	L	L	L	L	H	L	L	L	H	L
Political (Public Acceptance and Credibility)	M	L	H	L	L	L	H	L	L	L	H	H
Available Capital	H	H	L	L	L	L	H	L	H	L	L	M
Labor	H	M	H	M	H	M	H	L	L	L	L	L
Transportation	H	H	L	L	M	L	L	L	L	L	L	L
Materials and Equipment	H	H	L	L	M	L	L	L	L	L	L	L
Water	H	H	L	L	L	L	L	L	L	L	H	H

H = High Problem Area

M = Medium Problem Area

L = Low Problem Area

EXHIBIT 3 (Continued)

	Breeder		Gas Stim		Hydro		Geo- thermal	
	<u>'85</u>	<u>'95</u>	<u>'85</u>	<u>'95</u>	<u>'85</u>	<u>'95</u>	<u>'85</u>	<u>'95</u>
Research	H	L	M	L	L	L	M	M
Development	H	H	H	M	L	L	M	M
Prototype	H	L	H	M	L	L	M	M
Investment	H	H	H	H	M	M	L	L
Legislation	H	L	M	M	H	H	L	L
Political	H	H	M	M	H	H	L	L
Available Capital	L	H	L	L	M	M	L	L
Labor	L	H	M	M	L	L	L	L
Transportation	L	L	L	L	L	L	L	L
Materials and Equipment	L	H	M	M	M	L	L	L
Water	L	L	L	L	M	M	L	L
Transmission Lines	L	H	M	L	M	H	L	L

H = High Problem Area

M = Medium Problem Area

L = Low Problem Area

of a number of proposed processes should be heavily funded, it is unlikely that without a possible crash program the impact of this work will be significant before 1995.

The three generic categories of synthetic production — coal gasification, coal liquefaction, and syn gas production — have been examined in Exhibit 4. As can be seen from the table, we felt that until 1985 the research and development effort in these areas will be high. In the period 1985-1995 much of the development will be completed and the units will be in production. Because these processes are highly water consumptive and coal is often found in arid regions, considerable advance planning must take place.

Imports

The panel recommends that no effort should be made to cut off oil and gas imports entirely but that imports should be held to less than 15% of the total supply.

The panel feels that a program to make the U. S. completely independent of foreign sources would work against U. S. influence in international affairs. However, limiting the amount of imports would allow the country to function at an austere level even if some foreign supplies should be cut off for extended periods.

The major portion of present and future imported energy is expected to be furnished from Western Hemisphere sources.

OTHER ASPECTS OF THE PROBLEM

There were a number of very important aspects of the energy challenge that were briefly considered but not analyzed in any detail. Many of these items are fundamental, major and systemic to the achievement of Project Independence type goals.

A major policy commitment to central Federal planning, funding, and control is essential if the needed total systems approach to our energy goals are to be reached when needed. Major changes are required in the Federal, industrial, and public relationships from those envisioned under the philosophy of new federalism, free market, and decentralized decision

EXHIBIT 4
POTENTIAL PROBLEMS
SYNTHETICS 1985/1995

	Coal Gasification		Coal Liquefaction		Syn* Gas	
	'85	'95	'85	'95	'85	'95
Research	H	M	H	M	L	L
Development	H	M	H	M	L	L
Prototype	H	M	H	M	H	L
Investment	M	H	M	H	L	L
Legislation	L	L	L	L	L	L
Political	L	L	L	L	L	L
Capital	M	H	M	H	L	L
Labor	M	H	M	H	L	L
Transportation	L	L	L	L	L	L
Materials and Equipment	M	M	M	M	L	L
Water	H	H	H	H	L	L
Transportation Lines	L	L	L	L	L	L

H = High Problem Area

M = Medium Problem Area

L = Low Problem Area

* Syn Gas is a product of liquid petroleum.

making. Major changes will be required in the manner in which we use energy, where new concepts for treating "waste" are required. Total energy systems are needed where so-called waste heat is used to perform useful work. Materials must be recycled to save both materials and energy. More and more the closed cycle approach will be needed.

Although major contributions can eventually be made by fusion, hydrogen, solar, bio-conversion, etc., they were viewed as beyond the 1995 time period.

Also in the future, improved city planning with strong energy impact, improved low energy urban form designs could make our cities more efficient and more geared to closed cycle technologies.

Advanced Conversion

Very large savings in fuel consumption would also be possible if the efficiency of conversion of thermal energy to electricity could be improved. There are a number of ways in which this could be done, for example, higher temperature gas turbines, MHD and other advanced cycles.

We concluded that there was little likelihood that these technologies would make an appreciable contribution to energy supply prior to 1990. The necessary R&D should be done, however, to increase efficiency in both nuclear and fossil fuel systems in the future.

GROUP B2

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GROUP B-2

I. Introduction

To reach any 1985 goal other than complete collapse, planning for energy production and conservation measures in the coming decades must begin now. Even with planning, it is unlikely that we will be able to survive the next decade without a series of crises more pervasive in nature than the gasoline shortages of last winter. These future crises present both possibilities and problems. On the one hand, they will fire public interest in and understanding of the problems and help generate a commitment of national will to solving them. On the other hand, they will shake public confidence in their leaders and will provide forums for foolish behavior where devils are selected and executed. Because of the supply constraints of the next ten years, our best hope is to understand crisis management so that progress is maximized and foolishness minimized.

Although government must play a leadership role, the tasks ahead require a unique cooperative attitude between the public and private sectors. It would be a grave mistake to conclude that energy programs are equivalent to government programs.

The general strategy selected by the B-2 group was to rely heavily upon coal, nuclear energy, oil imports and conservation efforts for the short term, with a phasing in of clean technologies during the late Eighties and Nineties.

There was considerable debate about the desirability of nuclear power. Almost all people in the group felt that deployment of nuclear fission power plants had to continue through the Eighties because the near-term supply picture was so bleak that no option could be ignored. But because of the public debate concerning several of the safety and physical security aspects of nuclear power, there was substantial feeling that it should grow only to the extent required to make up the energy gap, and new plant construction should be phased out at some period in the Nineties as non-nuclear technologies and potentially fusion become available. Because of the difficulties associated with nuclear power in the public's

mind, capital may be more difficult to raise. The consensus was that more development should ultimately go into coal-based strategies.

A final general observation was that many of the strategies suggested for research and development could end in failure. Therefore, the group suggested that research money be widely spread among a variety of more promising strategies to allow us to select viable options. In present day terms, this suggests that the nuclear fission technology may be receiving undue emphasis to the detriment of other promising approaches. A nuclear disaster, whether accidental or deliberate, anywhere in the world could leave us with no contingency plan to fall back upon.

II. Demand

A. Near Term: To 1985

The group judged that demand for energy would be in the 105 to 120 Q range by 1985. Because this represents a slower rate of increase than traditional projections (which estimate about 130 Q by 1985), it is clear that conservation must be widely and diligently practiced. By a combination of "leak-stopping" and "belt-tightening" measures, it was estimated that demand could be cut by 17 to 30 Q below the traditional predictions.

Conservation thus represents the single most promising strategy for the country to follow in terms of meeting the supply-demand gap in both the short and the long term. It must be assigned the highest priority in research and development funding and in implementation plans.

B. Long Term: To 1995

Demand limitation in the long term permits more strategies -- social as well as technical -- to be undertaken. One debate, touched upon but not decided, was whether the nation should head for a highly centralized energy format with large production facilities and compact user-markets, or should it attempt to rely on a less vulnerable decentralized society, bound together by communication rather than by travel.

Changes of life style can affect energy demand reduction.

Decreasing or eliminating movements of people to and from work, working in the home, providing services near where people live, and substituting communication for transportation all are possibilities which require only small changes in existing cities; new towns provide even greater opportunities for energy efficiencies.

The group felt very uncertain in dealing with these questions since they raised social and political problems which no participant felt expertly qualified to define.

III. Supply

A. Near Term: To 1985

In addition to conservation, the group judged that the following actions were the most promising to take to assure supply through 1985:

- Double coal production -- 15 Q addition.
- Build nuclear plants now "in the pipeline" -- 17 Q addition.
- Search for and develop geothermal resources -- 1 Q addition.
- Recycle solid wastes -- 2 Q addition.
- Develop solar heating and hot water heating -- 2 Q addition.
- Nearly double hydroelectric capacity -- 2 Q addition.
- Increase imports of oil, natural gas, processed materials, petrochemicals and electricity.
- Keep even on production of domestic oil and natural gas.

The group felt that the A groups had already dealt with the positive and negative forces for each of these options or that they were already well known. Instead of spending time listing those factors, the group suggested these near-term actions which could be taken to insure that the supply objectives were met by 1985:

- Streamline governmental processes for licensing nuclear plants.

- Develop independent audit procedures to check closely on agency performance of waste management and security procedures to ensure uniformly responsible handling of dangerous materials from nuclear plants.
- Arrange means for swift international technical transfer so that the nation can benefit quickly from technology used in other countries (e. g., German mining technology).
- Begin training of adequate numbers of highly skilled personnel necessary for developing and applying new technologies (especially by creation of new mining schools). Use government subsidies, guaranteed jobs in government for graduates and fellowships at the National Laboratories as reservoirs for pools of talent which the nation will need quickly.
- Make certain that supportive technologies such as high-temperature, high-pressure valves are in existence as needed.
- Provide leadership and incentives (or potential elimination of disincentives) to the transportation industry in general and railroads especially to meet the national need for coal transportation.

B. Long Term: To 1995

The group concluded that there is very little to be done about the supply picture for most of the decade ahead. The real emphasis must be on the planning which will assure a supply in the Nineties and beyond; there the possibilities for change are greater. The following avenues are promising:

- Solar energy. An implemented technology has the potential for replacing heating, cooling and hot water loads for domestic and commercial sectors; those loads currently consume about 20% of the nation's energy. The non-polluting, inexhaustible nature of solar energy makes it particularly attractive.
- Geothermal electrical energy.
- Solar/biological and solar/wind technologies.
- Coal-based synthetic fuels, including environmental technology.
- The output of research and development not yet performed.
- Development of new innovative transportation infra-structure which will be necessary for material transportation of coal.

As can be seen from the above list, the basic strategy which the group suggested is that research funds be widely spread. That method adds stability by spreading the risk and finances a variety of options for choices later on. A consensus developed that, since all of the strategies which the group suggested were so difficult to execute, any "all your eggs in one basket" approach was unwise.

IV. A Special Word About Political Factors

The energy crisis in the United States is only part of a growing international problem in the supply of basic materials. U. S. actions in the area will inevitably affect other nations, whose perceptions of the motives and equitability of such actions will profoundly affect the future climate of international relations. An open attempt was made to understand and to take into account the differing political objectives of an integrated energy policy.

V. A Special Word About Reliability of the Data Base

The working group recommends that a national effort be made to check the data base for the summary information on oil, gas, nuclear, geothermal and coal resources of the nation. This effort should concentrate on the taking of baseline data rather than the summarizing of data taken by others. The data should be gathered by interdisciplinary teams sponsored by a disinterested national agency independent of the Department of the Interior or the Atomic Energy Commission; only one example of such an agency is the National Science Foundation.

VI. A Special Word About Legal and Institutional Problems

The law is only an instrument of social policy, so that many problems which are commonly identified as being legal problems are really problems of lack of national will in any particular direction. The courts must try to search for the national will, but are given little basis for knowing the correct decision. However, there are some areas where changes in legal processes could streamline energy decisions:

- Power Plant Siting: A national land use act which would encourage and help finance state and regional land use plans would shift the burden of power plant siting from private utilities to public bodies where it belongs.

- Consolidate departments with overlapping jurisdictions to assist in better decision-making.
- Streamline court procedures.
 - Provide for expected hearings.
 - Set time limits on bringing suits, together with wide publicity.
- Consider private property right/police power tradeoffs.

VII. A Special Word on Capital Expenditures and Financing

Assuming an annual cost of \$100 billion for energy capital expenditures, the method of financing must be given substantial consideration in order not to place undue strain on world money and capital markets. Due to the size and risks associated with the program, it will be necessary for sizable amounts of front-end capital to be provided by the government so that enough progress on the programs is demonstrated to allow entry to the domestic and offshore money markets. Currently, the U. S. capital markets have an annual capacity of \$110 billion and the eurocurrency markets an estimated size of \$350 billion. These markets will grow but, for the near term, probably will not support all of the annual energy expenditures desired without U. S. Government support. By 1980, thanks to oil producers' money and the credit-multiplying effect, the eurocurrency market could total \$1,000 billion. This does not take into account the fact that the U. S. oil industry is expected to generate \$300 billion of internal cash flow (depreciation and undistributed profits) by 1985 which can also be used to offset part of the annual \$100 billion of costs.

The near term costs will be most difficult to finance and require government assistance, but after 1980, and assuming the success of the program until then, the money markets will be developed to a size to allow the remaining annual expenditures to be financed through a well-engineered program. The source of repayment for the above financing will be the U. S. consumer, either directly or indirectly.

GROUP B3

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GROUP B-3

Introduction

A fundamental factor in the exceptional growth of the U. S. as a political and economic power has been the domestic abundance of cheap energy of various forms. This condition now no longer applies. Energy, indeed, occupies a unique place in the matters of concern to the national government. Because of energy's singular role, it may be necessary to develop and apply methods and policies that do not necessarily find consideration in more ordinary circumstances confronting the nation. One of these is the goal of securing domestic independence of energy supplies at rates which assure not only the survival but also further reasonable growth of the country. Consequently, a very long-term view has to be taken and means of policy may have to be included in government action that have not always been acceptable otherwise. One of these is undoubtedly the striving for the eventual independence of energy supply, a goal that may, for example, conflict with our present principles of international trade policy.

[EDITOR'S NOTE: The necessarily concise nature of the workshop reports resulted in the exclusion of some of the other concerns of the participants. In particular, some members of Group B-3 wished to have it recorded that there was considerable discussion during their deliberations concerning the problems of nuclear wastes disposal, protection of the environment, the impact of energy growth on society and the whole question of the wisdom of the nuclear option.]

Some members of the group felt that there needs to be an intensive investigation of the social impacts resulting from technological change.]

1. Energy Self-Sufficiency as a National Goal formed the framework for discussion. We would like to maintain the free market system of energy pricing as much as possible.
 - a. Near term reliance on nuclear and fossil fuels with long-range transition to inexhaustible resources such as solar, geothermal and fusion.

- b. Self-sufficiency defined as reducing from the present 20% energy imports (40% oil) to 5-10% energy imports by 1990.
 - (1) 5-10% level selected as reasonable to be met by "belt-tightening" measures in an emergency and is also the quantity coming from Western Hemisphere sources.
- 2. Methods for attaining self-sufficiency were listed under Resource Recovery, Resource Use, Research and Development and General.
 - a. Promising approaches, positive and negative factors, and near-term actions will be listed.

Resource Recovery

- 1. Place a floor under the price of imported energy (mainly oil, target to be investigated of \$7-8/bbl) to allow development of competitive domestic sources. The floor would be maintained by tariff on imports.
 - a. The price floor should be stable for 20-25 years to attract the required investment.
 - b. Positive effects include a more favorable balance of payments, international political stability, jobs provided at low skill levels, helpful to other energy-consuming nations.
 - c. Negative effects include increased domestic energy costs if foreign oil drops below floor, hindrance to expansionist oil-producing nations, and nations operating on cheaper foreign oil may undersell U. S. on manufactured products.
- 2. Federal government to be a major factor participant in cost sharing to reduce financial risks and to develop means for insuring that new energy-related technology is effectively transferred from research to commercial status.
 - a. The end result should be a commercial plant using new technology or a scaleable sized demonstration plant.
 - b. Positive effects include an acceleration of commercialization technology and better data for cost projections possible over all economies.
 - c. Near-term actions such as identification of priority processes requiring scaled-up demonstration and proposals to proper agencies for implementation would be helpful, as

well as educational regarding successful transfers of technology.

3. Assure adequate domestic uranium supplies, enrichment facilities and fuel cycle facilities for self-sufficiency.
 - a. May include higher price supports for uranium, planning and timely construction of new facilities as required to meet nuclear power needs.
 - b. Advantages include insurance against a shortage of nuclear fuel caused by political factors.
 - c. Near-term actions mostly involve education about need for self-sufficiency and convincing the government that these steps are necessary. Technology for more energy efficient facilities could be included in the program.
4. Deregulate wellhead price on new natural gas.
 - a. This would stimulate finding of more natural gas and price natural gas more realistically with respect to other fossil fuels. Higher gas prices would encourage conservation measures by users.
 - b. Costs to gas users would increase and a redistribution of gas use might be necessary. The latter may be desirable, and the free energy market would help in proper redistribution.
5. The government should address the problem of obtaining capital for a significant increase in electrical generating capacity for both coal and nuclear fueled plants.
 - a. Electric power plants are capital intensive, long lead items. Construction of new plants needed in the near term is lagging due to a lack of capital. Action is required to assure construction of power plants to meet our future needs.
6. The right of eminent domain for coal slurry pipelines should be secured.
 - a. Railroad interests or others should not be allowed to block construction of energy efficient transport systems where these are determined to be in the national interest.
 - b. An integrated energy transportation plan (near-term and long-term) should be developed for the United States so that conflicting interests may be identified and the conflicts resolved.

7. National needs should take precedence over states rights in energy matters.
 - a. Energy facilities such as oil refineries should be placed according to an integrated plan (with transportation, distribution, etc.) according to efficiency criteria rather than following the path of least local resistance.
 - b. Political realities may make this suggestion difficult to implement. Establishment of a logical national plan and education of citizens as to the national needs may help.
8. Amend the environmental protection law to allow more time for implementation of clean air standards. The delay would allow near-term recovery of energy from high sulfur fuels that would otherwise not be available.
 - a. Positive aspects include a more favorable balance of payments (from coal utilization rather than oil imports) providing jobs at low skills levels for workers involved in mining, construction, etc., and international political stability.
 - b. Negative aspects now include possible higher energy costs and higher environmental costs.
 - c. Technology developments could be aimed at more effective pollutant removal techniques in both the input and output to the combustion process.
 - d. A minority expressed the desire to work within the limits of the present law, perhaps accelerating required technology, and taking whatever penalties are imposed on the energy system under the law.

Resource Use

1. The government should set priorities for natural gas use in this order: 1) selected petrochemicals, 2) residential, 3) commercial, and 4) other.
 - a. All natural gas uses should be scrutinized for wasteful practices. Technology programs required to reduce waste should be recommended and performed.
 - b. The use of natural gas in electric power generation should be phased out as quickly as substitutes can be made available. Technology development should aid this process.

- c. A corollary would be setting of priorities for electricity generation fuels. Suggested were: 1) nuclear and coal, 2) hydroelectric, 3) geothermal, 4) oil, and 5) gas.
 - (1) Experimental programs such as wind power, biological conversion, etc., would be aimed at replacing oil and gas in electrical generation.
 - d. Natural gas supplies would be conserved, allowing more time for technology programs to find replacement fuels with a minimum disruption to the operating systems.
 - e. Setting of priorities becomes very complicated and can be illogical and unfair when specific allotments are made. It was noted that tobacco farmers are now guaranteed a 100% fuel allotment while ambulances are not.
2. Automobiles manufactured in or imported to the U. S. should be required to achieve a significant increase in gasoline mileage by 197X. (For example, an average of 20 mpg for a standard highway driving cycle compared to the 13.6 mpg average presently achieved.)
- a. Delay requirement for less than 2 gm/mi of NO_x until more energy efficient control techniques are available. Technology being done here should be encouraged.
 - b. Other suggestions for decreasing automotive fuel consumption included increased taxes on horsepower or weight and setting efficiency or passenger miles/gallon requirements. (Taxes could be applied to develop mass transit.)
 - c. The technology required to produce efficient automotive transportation should be emphasized.
3. Speed the implementation of electrified mass transit systems for urban areas with goal of moving people more efficiently.
- a. A corollary suggestion was to investigate energy efficient rail transit systems between cities and to support technology required.
 - b. Disadvantages included difficulty and expense of right of way acquisition and construction, a limited market of city people compared to the whole population, and technical difficulties that may decrease convenience.
 - c. Urban air pollution would be decreased, traffic jams would be eased, and oil energy would be conserved.

4. Research and Development
 - a. Government stimulate development of technology for an electric car as goal. Encourage production of special purpose urban vehicle.
 - b. Accelerate R & D on SO₂ removal (sulfur removal).
 - c. Accelerate R & D on nuclear waste. If not solved soon, consider phase-out or elimination of nuclear plants.
 - d. Federal energy R & D policy take heed of regionally specific opportunities (solar energy in California for example).
5. FEA/ERDA to be combined into Department of Natural Resources that is headed by cabinet level secretary to plan for short and long-range problems - constraints in manpower, materials, etc., and providing some priority for the necessary R & D.
 - a. Positive factors would include world stability based upon a known consistent energy policy, a stronger U. S. dollar due to positive planning, and the U. S. regaining its former strength.
6. The Federal Government to establish a program of Public Energy Education devoted to dissemination of facts upon which the people can form judgments about actions required both by individuals and government.
7. Emphasize basic theoretical science to improve basic knowledge and restore the depleted reservoir of basic scientific information needed for breakthrough on energy related research and development.
 - a. An example of a significant energy saving device is the transistor.
 - b. The nuclear fission breakthrough now is available to help us through the transition from exhaustible energy sources to inexhaustible energy sources -- perhaps as yet unimagined sources.

GROUP B4

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GROUP B-4

"THE PLAUSIBLE DESIRABLE SCENARIO"

Introduction and Scenario

Group A-4 worked with the given "Technological Advances" Scenario with an overlay of a set of moderate Project Independence requirements.

Group B-4 adopted a "Plausible Desirable Scenario" with a requirement only of maximum cost/effective development of domestic energy resources. The point is to examine the implications of a realistic optimism.

The "Plausible Desirable Scenario" used: 1) a 3.5% to 3.7% growth in GNP to 1985 and 1995, respectively, (this coincided with Scenario A-2); 2) Census E projection figures for population (total fertility rate = 2.1 replacement level only); and 3) an increase in energy efficiency and conservation of 1/2 to 3/4 percent per year. This is equal to a reduction of 10% to 15% in energy consumption per dollar of GNP by 1995. The D.O.I. projects a 10% decrease in Btu/\$ GNP based on composite historical trends; while World War II saw a decrease of 15%. This increased energy efficiency must go into increased productivity rather than just reduced services if the real standard of living is to increase.

The Scenario B-4 numbers are given in Table 1. The total energy per year was calculated from the formula:

$$\frac{\text{Btu/Yr}}{\$ \text{GNP}} \times \frac{\$ \text{GNP}}{\text{Capita}} \times \text{Capita} = \text{Btu/Yr}$$

The first factor is the inverse of the energy efficiency of the economy. The second represents the standard of living, and the third is the population. The total energy requirement in 1985 is 49 to 51 MM³/D and in 1995 is 67 to 70 MMB/D. The 106 Q demand for 1985 is appreciably lower than the NPC upper limit of 130 Q.

Table 1. Scenario B-4 Energy Demand (1958 \$)

	\$ GNP	Population	\$ GNP/ Capita	Energy Savings Per Year	Btu/ \$ GNP	Btu/ Yr (10 ¹⁵)	bbl Day (10 ⁶)
1974						77	37
1985	1,251B	236M	5300	1/2 3/4	85000 (82000)	106 (102)	51 (49)
1995	1,799B	256M	7020	1/2 3/4	80000 (76000)	146 (139)	70 (67)

Energy Supply

The energy supply in 1974 is estimated as given in Table 2.*

Scenario B-4 postulated for 1985 two domestic supply limits; an upper limit based on a fully accelerated funding of advanced energy development, and a plausible lower limit. These are given in Table 3. The 1995 energy supply table was not constructed because of time limitations; also the trends were expected to be the same to 1995. Moreover, it was

Table 2. 1974 Energy Supply (Est.)

Petroleum Domestic	12 MMB/D
Coal	6
Gas	10
Hydroelectric	1
Nuclear	1
Domestic Subtotal	30
Petroleum Import	7
Total Energy	37 MMB/D

* Preliminary data from "Short Term Analysis of Energy Options Available to the U. S., "Stanford Research Institute Report, 1974.

Table 3. 1985 Energy Supply MMB/D

		Upper	Lower
1974 Domestic		30	30
Additional Domestic Supply/Conventional			
Oil	Alaska North Slope	4	2
	Alaska, Gulf	1	0
	Santa Barbara	1	1
	Atlantic Coast	2	1
	Shale Oil	2	1/2
Coal		4	4
Nuclear		5	4-1/2
Hydroelectric		1	1
Subtotal		20	13
Additional Domestic Supply/New			
	Solar	1	1
	Tidal/Wind	1	
	Geothermal (steam)	1	
	Geothermal (rocks)	1	
	Shale Oil (in situ)	1	
	Coal (in situ)		
	Waste and Biofeedstocks	3	
Subtotal		8	1
Total Supply		58	44

felt that energy self-sufficiency is more likely at longer time periods. The 1974 petroleum domestic supply is assumed constant based on accelerated development and increased recoveries, principally as a result of improved economics of oil and gas recovery.

Additional Domestic Supply/Conventional

To bring in the additional domestic sources/conventional, the following factors must be present:

1. Positive incentives must be maintained for industry and finance.
2. Perception by the public must be accomplished, which probably require improved communication techniques between the decision-makers, technologists, and the public.
3. Perception includes cost effective adjudication of the environmental issues.
4. The Alaska Gulf and the Atlantic Coast exploitation require changes in laws and/or regulations. In this regard, on the Atlantic Coast, the local political problems must be resolved. The development of the Alaska Gulf requires utilization of advanced production technology.
5. The further development of the North Slope requires further exploration and increased pipeline capacity.
6. To accomplish the coal option requires surmounting the supply problems in equipment, transportation, skilled mine labor, and the socio-environmental issues involved in setting up new mining communities, as well as the requirements for uniform air and water quality standards across political boundaries.
7. To accomplish the nuclear option requires the removal of conditions which might motivate utility decisions to delay or suspend nuclear expansion plans. These include a possible continuation of current financial stringencies and siting and environmental delays, uncertainties regarding future capital and fuel costs, uncertainties regarding the timely availability of fuel cycle facilities for conventional reactors, including enrichment, reprocessing and waste disposal, and uncertainties regarding the economic feasibility of breeder systems.

Capital Costs and Financing

As independent analysis of the capital costs of the energy development programs included in this scenario was not undertaken. A recent extensive analysis of 1971-1985 energy development costs, prepared by the National Petroleum Council (December 1972), includes four cases

which exceed Scenario B-4. Their estimated capital costs, in 1970 dollars, ranged between \$451 billion and \$547 billion for the 15-year period studied. In a statement prepared for the Senate Interior and Insular Affairs Committee (March 6, 1973), an officer of Bankers Trust Company reported their independent estimates of energy development cases comparable with those of NPC, for the 13-year period 1973-85, as being between \$415 billion and \$476 billion, also in 1970 dollars. Similar conclusions were also reached in an NAE study. It would appear that these two independent estimates are in reasonable agreement, considering the difference in the time periods considered.

Bankers Trust also compared their year-by-year forecasts of energy industry capital needs with their estimates of the total amount of investment capital from the private sector, including individual and institutional investors, commercial banks and insurance companies. This analysis indicates that the annual capital needs average about 25% of the available pool of funds, and range between 22% and 29%. On the basis of this analysis, they conclude that "This amount could be easily absorbed by the capital market within that time period."

A special note should be taken of the present financing problems of the electric utility industry and what this implies in connection with its major role in the future. At the present time a combination of money market restraints and depressed equity values resulting from reduced rates of return induced by inflation and the quantum jump in fuel prices has put a severe strain upon the industry's ability to raise capital. Although these circumstances may be of relatively short-term duration, they clearly point the need for a more enlightened regulatory attitude. Rates of return pegged more realistically to capital costs, along with more prompt disposition of rate adjustments to accommodate increased costs of service, clearly are mandatory. If the regulatory process cannot become more responsive to these difficult conditions, there is considerable doubt whether the electric utilities can raise the capital needed for the expansion contemplated by this scenario.

Shortfall Alternatives

The 1985 Energy Supply Table indicates that the upper plausible supply of 51-53 MMB/D covers the demand of 49-51 MMB/D. The lower

limit of 42 MMB/D has a shortfall of 7-9 MMB/D. One MMB/D is equivalent (at perhaps \$10 per barrel) to \$3.6 B/yr. Thus, the projected shortfall is \$25-32 B/yr, with an importation level approximately equal to that of 1974, which was 7 MMB/D.

There are two alternative approaches to deal with the problems and risk inherent in the shortfall:

1. Develop additional domestic energy sources to avoid the necessity of importation.
2. Develop high technology which can be transformed into exports of products and expertise to offset foreign trade deficits.

The risk involved in importation should be analyzed and evaluated in an objective way, just the same as the risks in the nuclear or other energy options.

Recommendations

Additional Domestic Supply/New

Here, the recommendation is that wise full-scale development decisions will be well motivated by funding of pilot plant demonstrations of about 1/10 full-scale. New energy technologies can only have a fair evaluation in such comparisons. It is unreasonable to expect decisions based on extrapolation in new process technologies over 3 or 6 orders of magnitude from systems studies based on laboratory experiments to lead to the right choice for full-scale power plant development.

It is in this area that the government has its primary role both as innovator and sponsor by seeing that there is heavy industry involvement to provide continuity for deployment of full-scale plants by industry, where government cost-sharing may still be required.

With the change in the percentage make-up of domestic oil in the total energy summation, the distribution of energy use will change and the dislocation technologies will require analysis and development.

High Technology Export Products

NASA's role of providing the leading edge of aeronautics and space application technology should be heavily emphasized and expanded. High technology products (aircraft and computers) have made up the largest single manufacturing export category in recent times.

NASA should expand its efforts in this area to help the United States develop new aeronautical products, including energy conservative aircraft, and thus help to maintain a viable position in the world market place.

NASA's patent methodologies should be re-examined to see if they can be better structured to encourage innovation in the export sector.

GROUP B5

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GROUP B-5

SUGGESTED U. S. ENERGY POLICY

I. METHOD

The problems, objectives and constraints of the total fuel picture with a 1974 baseline reference was used as a reasonable approach to define the portable fuel distribution requirements for 1980, 1990, and 2000.

The model used in this evaluation consisted of five steps (Figure 1):

- 1) Objectives are selected
- 2) Actions alternatives are identified
- 3) Generation of a scenario consistent with existing facts and (investigated) projections
- 4) Design recommended policy
- 5) Implementation with feedback to Item 1

* * * * *

The "objectives" were analyzed and a number of categories emerged:

- 1) Optional mix of government versus free enterprise as determined by a democratic group
- 2) Project Independence as modified to allow a 5% fuel oil import
- 3) Maintain a (minimal) means of mobile life style avoiding dislocations
- 4) Maintain strong defense posture
- 5) Plan for an evolutionary attainment of mobility
- 6) Equitable and peaceful achievement of change
- 7) Offer assistance to other nations in obtaining desired mobility
- 8) Make mobile life style more universal in U. S.
- 9) A gradual substitution of petroleum fuels by other energy forms
- 10) Control (minimize) environmental insult.

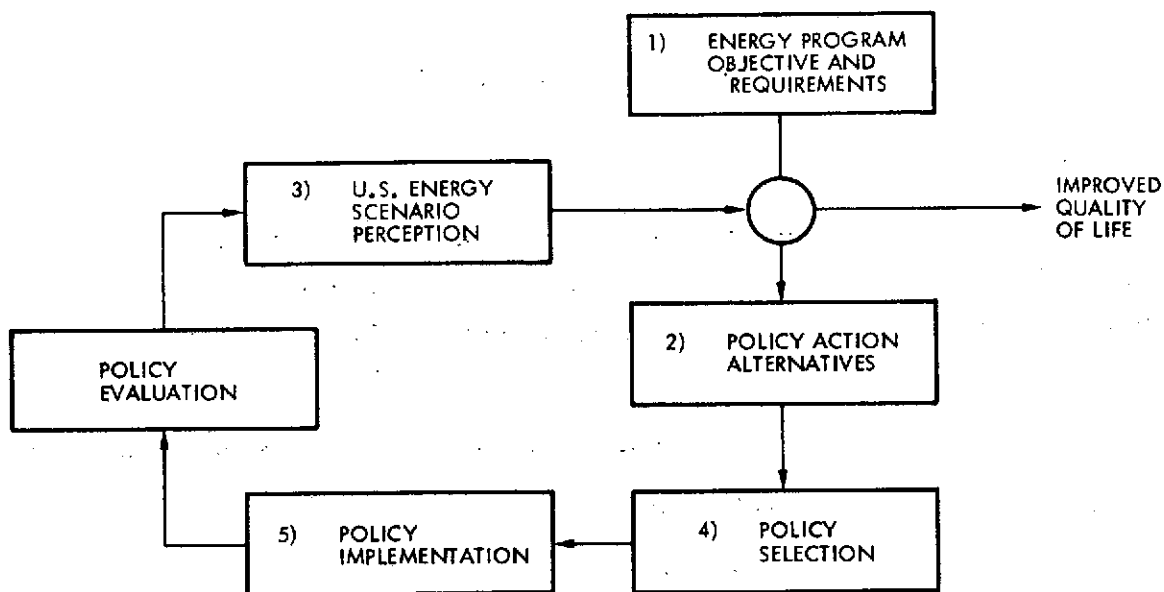


Figure 1. Method for Selective U.S. Energy Program

When making a statement of the problem, the following influencing factors appeared relevant:

- 1) If we continue our present rate of growth with no positive energy plan in effect, we cannot enjoy the assurance of adequate portable energy fuel.
- 2) The inevitable shortage will have adverse social consequences in the U. S.
- 3) The importation of portable fuel in excess of 5% can invite international blackmail.
- 4) The lack of proper energy planning and subsequent implementation can lead to hostility among the free world and the developing countries.

Specific near term objectives and constraints:

- 1) The need for an evolutionary change from present balance of energy use and distribution.
- 2) Fiscal support should be limited to $\leq 15\%$ of GNP to allow pursuit of other national objectives.
- 3) Trained manpower, both professional and vocational.
- 4) Time scale based on 10 year milestones.

- 5) Resources — use of available proven and inferred reserves to buy time.
- 6) Use of existing and future technology.

II. GROUP B-5 — SCENARIO

In developing and evaluating rational actions and logical alternatives for incorporation in a national energy policy, it was first necessary to establish a reference framework or scenario of the future (Table 1). This framework includes economic, social and energy factors and variables projected to 1985 from a 1974 base. Projections to 1985 were developed by recognizing current trends. These projections were further divided into two sets of conditions; namely, the most likely status in 1985 without a national energy policy, and a desired set of conditions with such a policy.

Table 1. Group B-5 — Scenario Data

	Factors/ Variables	1974 Level	Trend	1985 Projection	1985 Desire
Economic	GNP	$\$1.3 \times 10^{12}$	Increasing Slowly		Growth Rate at 2%/Year
	Unemploy- ment	6%	Increasing to Plateau	?	→ <4%
	Inflation	CPI = 180 (1967)	Increasing at 10%/Yr		→ <3% / Yr
	Interna- tional Money Exchange	Deficit at ~ $\$9 \times 10^9$ / Yr	Increasing	$\$20 \times 10^9$	-0-
Social	Population	205 MM	Increasing Slowly	225 MM	
Energy	Petroleum Demand	18 MM BBL/Day	Increasing	27 MM BBL/Day	20 MM BBL/ DAY with conservation
	Total Demand	75Q/Yr	Increasing	120 Q/Yr	100 Q/Yr with conservation
	Btu/Cap.	0.3×10^9 Btu/Yr	Steady		$\sim 0.45 \times 10^9$ / Yr
	Energy Cost*	8% of Personal Income	Increase	15%	10%

* Per cap. cost percentage of personal income.

Technological Variable for Energy	Present Status	Trend	If No Action	Needed by 1985
Oil	High Technology	Increasing	Inadequate	(a) Reach deeper reserves on OCS (b) Reach distant reserves (c) Secondary and tertiary recovery
Coal Extraction	Low Technology	Increasing	Adequate	- -
Use	Moderate	Increasing	Marginal	Minimize environ- mental insult by means of land recla- mation and reduction in SO _x emissions
Coal Conver- sion to Gas	Low	Increasing	Inadequate	Improved efficiency and water resources management
Coal Conver- sion to Oil	Low	Increasing	Inadequate	Doubtful availability by 1985
Geothermal	Low (50 MW)	Increasing	Inadequate	Exploration; develop- ment of most prom- ising techniques → 30,000 MW
Solar	Low	Increasing	Inadequate	Solar heating and cooling competitive w. electricity or gas
Waste Conversion	Moderate	Increasing	Moderate	Quasi-political action needed to implement (~7 Q potential)
Nuclear	Moderate	Increasing	Moderate	Need acceptable method of waste disposal

III. SELECTION OF ALTERNATE ACTIONS AND POLICIES

A) Macro Options

1) Conservation

- Can achieve 15-20% without deleterious impact on present life style.
- Efficiency/innovation of equipment can gradually superimpose on direct actions to reduce energy draw.

2) Substitutions

- Coal for petroleum:

15 Q potential by 1985

- Solar heating/cooling in many areas:

1 - 2 Q by 1985

- Nuclear for coal/oil/natural gas:

10-12 Q in 1985

30 Q by 2000

3) Change social/business forms of personal contact-communication

B) Mini Options (Portable Fuel)

1) Improved commercial transportation

2) Create effective intermodal transportation systems. More efficient long haul traffic/short haul alternatives

- Load factors
- Traffic control
- Interconnects

3) Alternate power sources - electric cars/trucks/buses for urban use

4) Reduce transportation

5) Improve communication

6) Allocation of fuel

7) Smaller, lighter, lower horsepower, more efficient vehicles.

IV. DESIGN OF RECOMMENDED POLICY

The estimated energy use pattern for 1974, when compared to the savings that could be realized by incorporating reasonable conservation measures, reveals a gradual but positive increase in savings to almost 20% by the year 1990 (Table 2).

Each element of total U.S. energy consumption in Table 2 was analyzed in respect to efficiency of source and also as to specific energy saving potential. Overall conservation of demand was then estimated by weighted average consumption. The results are plotted in Figure 2.

The group then addressed itself to a reasonable approach to meeting what was concluded to be the real need of the nation if conservation were practiced as prescribed; if quality of life was to be maintained; and if domestic energy sufficiency was to be achieved.

Figure 3 illustrates the total U.S. Q estimated to be used by the year 2000. Without the recommended conservation measures, the total Q will reach 119 in 1985 and 140 Q by 2000. This is based on a population of 225 million in 1985, 250 million in 2000 and a gradual increase in per capita Btu consumption from 0.30×10^9 Btu/yr in 1975 to 0.45×10^9 .

Using sound conservation measures the total of 140 Q can be reduced to 112 Q needed in the year 2000. How will this "minimal" demand

Table 2. Energy Use Pattern

Use Area	% '73 National Use	Estimated 1990 % Saving*
Transportation	25	25
Space Heating	18	18
Process Steam	16	10
Direct Heat	11	20
Other	30	20
Total	100%	20%

* Saving in 1990 achieved by conservation

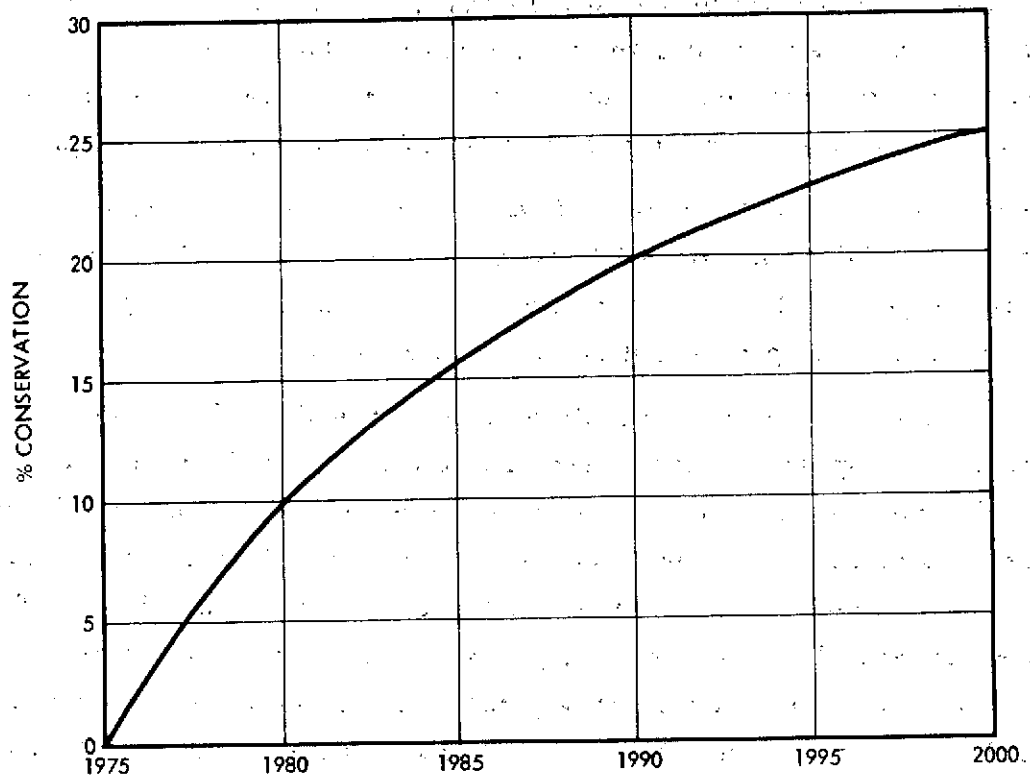


Figure 2. Conservation of Energy Consumed

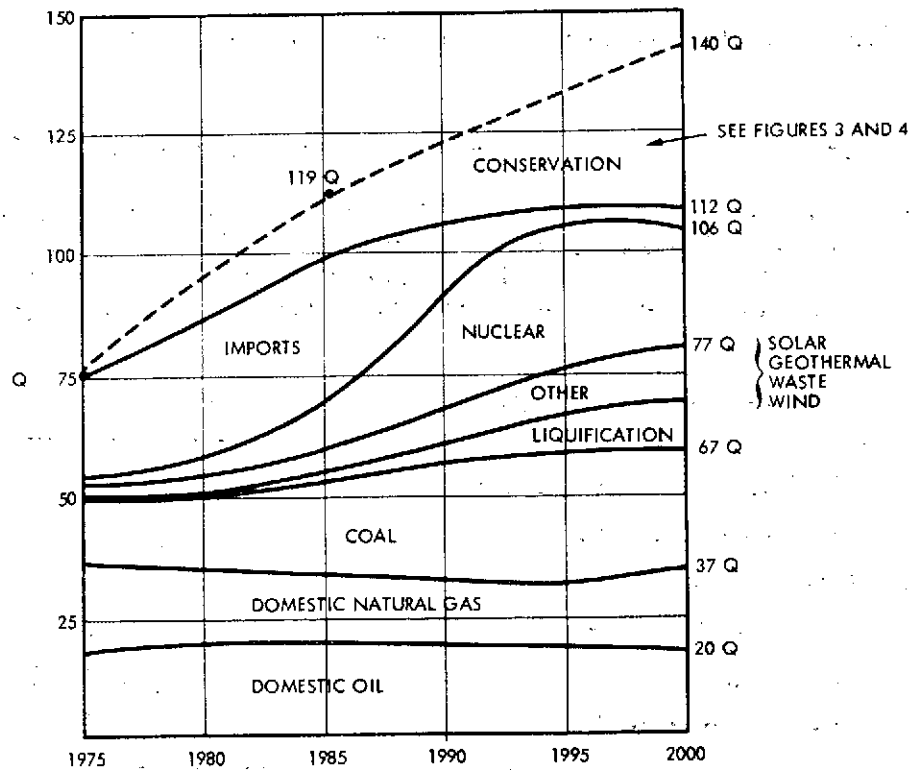


Figure 3. Total U. S. "Q"

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be met? Domestic oil providing 20 Q in 1975, cannot reasonably be expected to expand beyond 20 Q in 2000, even with heavy emphasis on exploration, remote and deep wells. For the same reasons, domestic gas productions will go from 20 Q to at best 17 Q during this time period.

Coal developed to its fullest potential with western strip mining and implementation of deep mining will not yield more than 1.2 billion tons/yr or 30 Q by the year 2000. All other sources, including solar, geothermal, etc., are estimated to give about 10 Q by year 2000.

In an effort to meet our objective of reducing U.S. dependency to a minimum, oil imports from the eastern hemisphere will remain at 5% or 6 Q. Alternatives were examined to achieve the remaining 30 Q's to reach the total of 112 Q in 2000. Table 3 lists these alternatives. The group concluded that nuclear energy must supply >15 Q if quality of life and Project Independence sufficiency goals are to be met as desired. Having realized this conclusion, it was felt that no significantly greater risk would be involved in developing nuclear energy at the full 30 Q level. Moreover, more sophisticated nuclear energy will be needed in the 21st century, e.g., breeders and fusion.

In considering the use of portable energy as in Figure 4, three main points were made:

- The principal source of energy for transportation in 1975 is oil.
- 25% of the total Q in 1975 (~18 Q) was directed toward portable energy use. It was estimated that at least 20% of the total Q in the year 2000 (or 22 Q) will be directed toward transportation after considerable conservation measures have been applied.

Table 3. Alternatives for 30 Q in 2000*

1.	Nuclear	Must Have	≥ 15 Q
2.	Solar-Direct Extra		≤ 10 Q
3.	Coal Extra		-0-
4.	Biological (Solar) Extra		≤ 2 Q
5.	Waste Extra		$\leq 7-10$ Q
6.	Other (Unknown)		≤ 2 Q

* As substitute for nuclear

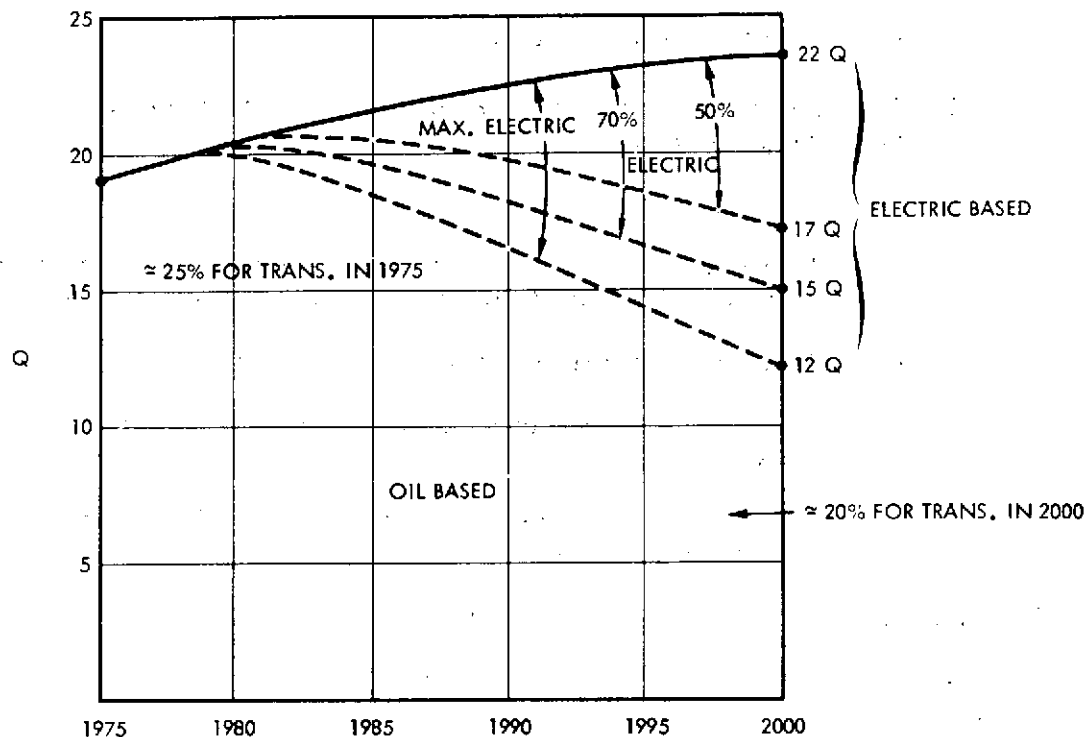


Figure 4. Portable Energy Q's

- To maintain independence from foreign sources and still meet the oil demand in the year 2000, the group suggested that we must shift a large percent of oil-based ground transportation to other forms, e.g., electric power.

V. IMPLEMENTATION OF ENERGY PLAN

A) What and When of Recommended Strategy

- 1) Promote conservation of general energy usage to achieve 10% savings in 5 years, 20% savings in 15 years, and 25% savings by year 2000.
- 2) Aim at all-out coal production as soon as possible – control environmental insult – liquefaction by 1990's – recycle process water.
- 3) Institute nuclear power program as soon as possible – up to 30 Q by 2000.
 - a) Replicate light water, thermal neutron reactors
 - b) Begin high temperature gas cooled reactors

- c) R&D safety, waste disposal or recycle of wasted
- d) R&D breeders, fusion
- 4) Develop solar, geothermal, etc., wherever feasible, as soon as possible.
- 5) Portable Energy
 - a) Go electric/battery vehicles in urban ground transit by mid 90's - use train piggy-back for interurban
 - b) Promote urban mass transit (electric)
 - c) Develop efficient intermodal mass transport on a systems basis
 - d) Promote lightweight, low horsepower A/C and ground-transport vehicles.
- B) The How of Implementing the Strategy
 - 1) Strong government leadership
 - a) Tax program
 - Reward conservation
 - Tax energy users (progressive rate structure)
 - Reward investment in energy R&D
 - Reward investment in domestic energy exploration and production
 - b) Establish energy savings bonds programs
 - c) Develop strong, consistent federal energy policy
 - d) Guarantee prices and markets for new energy sources and fuel forms at levels which attract private investment
 - e) Fund a broadly based energy R&D program now with emphasis on coal gasification and liquefaction, nuclear, and solar power development
 - f) Educate public in energy need and policy.
 - 2) Direct creation of energy sources and plants largely by private sector, but with some government ownership:
 - a) When economic viability, safety, or environmental impact is understood and predictable, emphasize

efficiency and encourage the private sector to build the plants.

- b) When safety, economic viability, or environmental impact is uncertain, let government own part or all of plant (reserve mining).
- 3) Portable Energy
 - a) Federal subsidy of mass transit systems encouraged.
 - b) Heavily tax inefficient oil powered private ground vehicles.
 - c) Institute government R&D programs to develop electric powered vehicles and lightweight vehicles.
 - d) Institute government public information programs on need and character of portable fuel strategy.

VI. CRITIQUE AND CAVEATS

A) Critique by recommended policy

- 1) Reliance on western coal and shale requires use of water in water short areas -- concerned about impact on food production and environment.
- 2) R&D of breeder reactors should be continued to create options, but without commitment to deploy until safety and other impacts are understood.

GROUP B6

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GROUP B-6

This report is divided into discussions of supply sources, better energy uses, and the reconciliation of supply and demand.

Our evaluation of the present political system has led us to believe that a long-term decline in per capita energy consumption would not be acceptable to a majority of our politicians. Starting with this constraint, we confine ourselves at first to a consideration of a U.S. society which grows in energy consumption at a rate between 0 and 5% per year. The exact growth rate will, to a large extent, depend upon national policy and political and personal decisions. Then, within the context of this society, we developed an energy supply and demand system, and examined the consequences of this system. This exercise was pursued to permit an interdisciplinary dialogue on complex issues as well as to encourage unconventional analysis.

Domestic Supply

A matrix was developed (Appendix A) which permitted all the known potential fuel resources to be semiquantitatively examined and compared in terms of technical feasibility, potential short and long-term* contribution to supply, and cost. From these data, it became very clear that the anticipated increase in U.S. demand could only be satisfied domestically by a combination of offshore oil, strip-mined coal, and nuclear power. Of the three, the last two would be most important. By comparison, all other sources combined including shale oil, would make only a small contribution to the anticipated incremental demand. Moreover, it was recognized that for the proper utilization of the produced coal, it would be necessary to rapidly bring coal conversion plants on stream.

Having focused on offshore oil, strip-mined coal, and nuclear power, these fuels were further evaluated (+3 is beneficial, -3 is detrimental) in terms of their impact on: the environment, social dislocations, unemployment, land use, and drain on other material resources.

* Short-term = 11 years
Long-term = 20 years

	<u>Environment</u>	<u>Social Effects</u>	<u>Employment</u>	<u>Land Use</u>	<u>Other Resources</u>	<u>Total</u>
Offshore oil	0	0	2	-1	-2	-1
Strip-mined	-2	-2 1/2	2	-3	-2	-7 1/2
Nuclear power	-3	-2	2	-2	-2	-7

It was concluded that offshore oil had a small negative impact on these social factors, and that both strip-mined coal and nuclear power had large negative impacts.

Better Use of Energy

On the demand side, a number of technological options were considered for accomplishing the same task with less energy input. While we considered them in the matrix format, time and the data base available did not permit the level of detail used on supply. A description and summary of remarks follows.

Efficient Conversion

More efficient internal combustion engines could save some fuel, but environmental constraints are a counterforce. Small cars are more promising, and in the long run, will afford us double the mileage per gallon.

Electric vehicles will not exceed 5% of all vehicles by the year 2000. They are expensive, and they are not fuel saving in source energy, but permit substitution of coal and nuclear for oil.

Industrial processes are improvable with investment in technology and plant equipment. It was estimated that general industrial fuel requirements per unit output can be reduced about 20-30% by the 90's.

Use of Waste Heat

Electricity generation plants conventionally convert 25 to 40% of the fuel to electricity and the remaining 60% or more to low-grade heat which is thrown away. In the total energy concept, we make a little less electricity; the remaining heat energy is higher grade and so can be useful for

space heating and water heating. This could potentially make use of 85% of the fuel energy and replace gas and oil normally used for space heating. This total energy concept could be a major conservation means, but institutional time lags and the need for storage technology for large quantities of heat will slow its growth until the 90's without R&D.

While the above options require some tradeoff between capital invested and energy saved, the following are more general tradeoffs among energy/capital/labor/convenience:

- Mass transit involves very massive capital investment to achieve more passenger-miles per gallon. The net energy effect is considered uncertain.
- Better building practices, through building code constraints, or by voluntary action can make substantial savings in space heating and water heating by better insulation, reduced infiltration, sun-control, etc. Multidwellings and smaller houses for higher population density can decrease needed energy per capita.
- Energy storage alternatives for electric utilities, including batteries, pumped storage, compressed air, hydrogen, flywheels, etc., provide a tradeoff between capital and fuel costs to achieve the peaking requirements of a utility.

Energy Use Built on a Principle of No-waste

Besides the technological solutions to demand reductions, there are ways of altering behavior patterns to reduce energy use. Available estimates of energy saved based on patterns of no waste range from 15 to 62%. Clearly, it matters who is saving and where. During nine months of 1973-74, the domestic agencies of the federal government saved equivalent to 75 million barrels of oil with a dollar savings of \$600,000,000. Simple thrift was the operating principle. In the discussion of thrift, our group argued for using such simple measures when available, rather than looking for more complicated solutions, a sometimes characteristic of the highly educated.

Also in need of underlining is the observation that waste from the point of view of the consumer is often sales from the point of view of the producer. Ours is an economy built on waste. Cutting waste may be viewed by producers as equivalent to cutting sales. A no-waste economy would emphasize growth in quality, rather than quantity, and growth in the service areas where we lag and where the energy cost is low. Libraries,

for example, are understocked, understaffed, and underused. Thus, in addition to no-waste, this group calls for quality growth, particularly in the half-starved service sectors of our economy.

Although we recognize that estimates of conservation or no-waste are uncertain and perhaps optimistic, we can see no serious dangers either to individual health or to the environment of a no-waste policy. Indeed we can project a healthier society and a strong economy that might result. No waste not only might increase productivity, but it would move the nation in the direction of certain ethical changes that will, in any case, increase our adaptive abilities in any future characterized by scarcities. It is often argued that no waste does not change our life style; we need studies exploring positive consequences that might result. In our discussion we listed areas where both individuals and institutions could redirect energy use, but to give root to such redirections the leadership in this country must not behave in such a way that contradicts their preachings: in other words, we must not only preach what should be practiced, but we should practice what we preach. Role modeling is important; a leadership which encourages the production of durable products, the dropping off of gadget prestige, and which produces the incentives to so do is a leadership which will be listened to as credible.

Our group was fully aware of the potential for our work ethic to be given new *raison d'être* in a productivity ethic that encourages quality work, and encourages competence rather than time punching. It is believed that only within such changed perspective of leadership that mechanisms for change, such as schools, will be able to successfully carry out educational goals that will be found to be supportive of a structure which is indeed practicing what it preaches and avoiding the contradictions that tear great nations apart.

While no detailed breakdown of the potential savings in energy from these options was available, an overall estimate of 8 million barrels per day by the 90's was supplied by a panel member from an internal study.

Energy Balance

When a routine supply/demand balance was made, using all of the conventional wisdom at our command, and when all of the usual

conservation practices were superimposed upon this balance, it was found that by the turn of the century we not only still require imports (though small), but we also have committed the nation to a large strip-mining and nuclear heritage.

On a life-as-we-know-it basis, growing at something near the historic pattern that we have come to expect, there appears to be only one way to escape the negative social aspects of coal and/or nuclear developments — that way is to make the necessary political and economic agreements of imports at a bearable price. However, when we reflected on the corresponding increased demands that will arise from the rest of the world, and as we made allowances for the reluctance of middle easterners to deplete their reserves too rapidly, we concluded that oil imports are probably not going to be the solution to the U.S. energy problem (over and above any consideration of military posture).

We thus came to the conclusion that we must accept nuclear power and strip-mining or face the consequences of foregoing the use of the energy that either or both provide. It is in this last step that new insight is gained: While we can estimate the energy loss to the nation, we cannot evaluate the social and economic impact of that loss. This last statement is very important. What do we gain by taking the environment risks that go along with coal and nuclear power? Are we buying freedom from massive food shortages, unemployment, and economic disaster; or are we simply buying an unnecessarily high level of affluence. A penetrating study is needed to this critical question before a rational decision on supporting nuclear power can be made.

There was a minority position expressed on the use of nuclear fission power. The position taken essentially argues that there is no possible reason for risking life for successive generations by the use of a technology which is based on the infallibility of man and which threatens the form of government which we now have. The background for this view has been provided by the minority member, and is attached to this report.

Conclusions

1. The only domestic energy sources with sufficient potential to maintain the nation in its historic growth pattern are stripmined coal and nuclear fission.

2. If we forego the use of either of these energy resources, we will enter a period of negative per capita energy consumption.
3. We do not believe there is an adequate data base from which to construct a picture of our society under negative per capita energy consumption. We, therefore, cannot rationally decide on whether to accept nuclear risk or a restructured society stemming from negative per capita energy consumption.
4. We conclude that the middle East is not a feasible source of sufficient energy to allow us to escape a decision on alternatives mentioned in 3.
5. We need a reliable analysis of the social consequences of negative per capita consumption and suggest that reliability may be increased by including talent that reflects experience with a variety of societies and cultures.
6. A no-waste ethic induced by government, would facilitate a better understanding of what we will be up against in using conservation as an energy-saving tactic in industry and smaller and individual units.

APPENDIX "A"

Projected Effects Of Alternative Potential Actions *

	TF	ENERGY ST LT Mil./Scale bbls	C	Emp.	Env.	SE	LU	MR	RD	PF
<u>Supply</u>										
Oil										
On-shore	3	1/1	-1/-2							
Off-shore	3	1/1	3/2	2	2	0	0	-1	-2	-2 +3
Coal										
Strip	3	6/2	10/3	3	2	-2	-2 1/2	-3	-2	-1 +1
Under-ground	3	2/1	3/2	2						
N. Gas	3	-3/-1	-5/-2							
Nuclear	2	12/3	18/3	3	2	-3	-2	-2	-2	-1 +1
Shale	1	1/1	4/2	2						
Heavy Oil	1	1/1	1/1	2						
Solar										
Heat	2	0/0	2/2	1	0					
Elect.	0			0						
Geothermal	2	0/0	0/0							
Waste	3	0/0	1/1	2						
<u>Conversion</u>										
Coal/Gas										
Hi Btu	0+	0/0	4/2	1						
Lo Btu	2	1/1								
Coal/Oil	-1	0/0	1/1	1						
Coal/Meth	1	0/0	1/1	1						
Coal/H2	1	0/0	1/1	1						
Nucl/H2										
Thermal	2	0/0	1/1	1						
Electrical	-2	0/0	1/1							
<u>Efficient Use**</u>										
IC Engines										
Elect. Vehicle										
Industrial Processes										
Total Energy systems - eliminate waste heat										
Energy parks										
<u>Land/Capital/Energy Tradeoffs**</u>										
Small Cars										
Mass Transit										
Construction Codes										
Control Peaking by Storage										

*Definition of terms follows.

**See text for explanations

Explanatory Notes

TF = technical feasibility

+3 = large-scale production demonstrated

:

+1 = pilots, demonstration projects exist

0 = not certain

Energy ST = potential contribution to increment in supply of energy in short term (before 1985)

Energy LT = potential contribution to increment in supply of energy in long term (1985-1995)

Both are expressed in terms of millions of barrels of oil equivalent per day and in terms of a rating scale, where:

+3 = >8 "MMB/D COE"

+1 = 1 "MMB/D COE"

+2 = 2 to 8 "MMB/D COE"

+0 = 0 "MMB/D COE"

C = cost

cheapest +3

most expensive 0

Empl. = employment

+3 = no problems in regard to availability of labor
dislocation of labor; other employment patterns

0 = skills not available

Env. = environmental effects

+3 = very beneficial

-3 = very harmful

SE = social effects

This scale is a summary of the following elements:

- Consequences for federal or central control
(due to need for safety provisions or for regulation)
- Consequences for population displacement, migration
- Consequences for such political issues as water rights;
states rights; international problems

+3 = beneficial socio-political effects

-3 = harmful socio-political effects

LU = land use effects

This scale is a summary of the following elements:

- Consequences for difficulties in land acquisition
- Consequences for alternative productive uses of land
- Consequences for aesthetics

MR = material resources (steel, copper, aluminum, etc.)

Effects on other resources employed in production and implementation, i.e., extraction, conversion, transportation, consumption

+3 = no major problems in deployment of these resources

-3 = major problems likely

RD = resource depletion

+3 = no direct depletion of energy resources

-3 = much depletion likely; resource likely to be expended

PF = effects on supply of portable fuels

+3 = beneficial effects

-3 = harmful effects

Minority Report B-6

This minority report calls for a moratorium on all further construction of nuclear fission plants, and sees these plants as unsafe, unnecessary, and unreliable. Major safety problems having to do with waste, fuel reprocessing, sabotage, terrorism, and competent management are due to the fallible nature of Homo sapiens, unsolvable in this view. The phasing out of all present nuclear plants, which at the present time produce only a very small part of the nation's energy needs, is seen as high priority. Immediate implementation of conservation plans is needed to cover both consumer and industrial processes in the use of oil, gas, coal, and limited use of solar and geothermal in order that we may realistically assess future possibilities.

There are many examples of problems inherent in unreliable performance of nuclear plants. There are many plants that have been shut

down for long periods, and the long-term requirements and costs of repair to such plants have been recognized as serious problems by utilities experts. More important, one nuclear catastrophe is likely to lead to a shutoff of all nuclear plants, and leave the nation's economy in difficult straits if there is no contingency planning.

This view does not support the position that reliance on nuclear power plants should continue in the short term or until other alternatives become available, for good psychological and sociological reasons. Cultural change in the United States is more likely to come about through stress, such as illustrated by last winter's energy crunch. It is argued that only by removing the reliance on nuclear, by completely phasing out the present plants, can we phase in solar, geothermal, or anything else. Phasing out nuclear provides higher priority and incentive for exploring alternatives which to date have not been sufficiently explored because nuclear plants have been presented as a panacea for energy needs.

Finally, this position argues that the dependence on nuclear power is "downright un-American" if the full political consequences of nuclear energy are considered. An economy heavily dependent on nuclear could gradually lead to a change in form of government, from a democratic to a centralized, arsenal state reminiscent of the government of the early irrigation societies. Safety will be the responsibility of an internal federal or industry police force that will guard the nuclear plants, the diversion of materials, etc. This regulation is qualitatively different from good regulation of other industries where policing is of a different nature entirely.

Minority Report B-6 (Pro-Nuclear)

Most of the twelve groups concluded that further increases in nuclear energy use would be necessary, but should be viewed with great caution. Over three pages of minority dissent in Groups A-2 and B-6 are devoted to the anti-nuclear extremist position: that it is unsafe, unreliable, and unnecessary. It seems fair that "equal time" be given to the body of opinion, which this dissenter feels is more soundly based, that nuclear fission energy is necessary, safer than other available energy forms, and more reliable than comparable fossil fuel plants.

There has been a strong polarization produced by the nuclear/anti-nuclear controversy which has produced examples of oft-repeated falsehoods being regarded as proven facts. Such generalities as "everybody knows that nuclear plants cause cancer" and "plutonium is the most poisonous substance known to man" which have been repeated in the press are probably untrue (References 1 to 5). Similarly, the tendency to impune motives should be dismissed. It is at least as ridiculous to maintain that a scientist or legislator who believes nuclear energy is safe and necessary, is a "bought" person motivated by personal gain as it is to suggest, as a Congressman did at the Workshop, that an anti-nuclear advocate with expenses paid and many honoraria for speaking, has his own pecuniary motivation. This dissent is a personal view, not that of any group or company.

Safe

A number of groups and teams^{1, 2, 3, 4, 5} have examined nuclear benefits and risks objectively and carefully and reached the conclusions that:

- "1. During normal operation, nuclear plants pose less risk to public health than coal or oil fired electric plants.
2. The risk to the public, for the worst hypothetical accidents for both nuclear and fossil plants, is less than most of the risks society has historically accepted."¹

"The Nuclear Debate: A Call to Reason" (Reference 1) is by a number of scientists and engineers, some with former association with the Union of Concerned Scientists and the New England Coalition on Nuclear Pollution. The Rasmussen report (Reference 2), sponsored by the AEC, is the most comprehensive reactor safety study yet made, and reaches similar conclusions that catastrophic risks are much less than previous studies that "deliberately maximized risk estimates," and that different levels of catastrophic risk are three to four orders of magnitude less than for comparable deaths or damage by air crashes, large fires, explosions, and dams breaking. These are 1974 references; earlier documentation can be found over the past twenty years by starting with the references cited in these.

The search for zero risk is futile. We must deal in comparisons, and in this perspective weigh risk with benefits as we do in every action in our lives.

With as many as 500 million kilowatt nuclear plants in operation, the lifetime radiation hazard to the average citizen is much less than the risk in any of the following:

- Smoking three cigarettes a year
- One dental or medical X-ray in a lifetime
- Ten hours of jet flying in a lifetime
- Living in a granite or brick building for six months
- Visiting Colorado one day a year
- Being one-quarter ounce overweight

Some of the major catastrophies postulated as "possible" have a calculated chance far smaller than a major meteor eradicating a city or even a nearby star exploding as a nova, eliminating all life on earth. Neither of these has happened; nor has any operating nuclear plant had any accident involving loss of life.

Reliable

The dissenters confuse various effects affecting availability of nuclear and fossil plants. In the first few years new plants, particularly those larger than previously built, have lower availability than in the remaining 25 to 35 years of their life. Large new nuclear plants are being found to be as reliable or more reliable than fossil coal and oil plants of comparable size and "vintage." The implication that the nuclear components of the plant are unreliable is doubly misleading; it is usually the turbines, generators, and peripheral equipment that have caused unavailability.

Commonwealth Edison of Chicago, who has the most reactor-years of operating experience, has found the availability of their nuclear plants to be higher than their comparable coal plants. This is one reason why they are currently profitable and less hard pressed for capital than utilities that did not go as early to nuclear plants.

Necessary

This dissenter does not believe that future energy growth in the U.S. and in the world should or will continue indefinitely at the current or recent rates. There have been plateaus in the past of constant energy per capita; there will be one or more such plateaus in the future. Conservation of energy and improved energy efficiency are desirable goals in themselves as the economics of extraction, distribution, and generation of energy changes. However, a doubling of annual energy consumption in the U.S. and a tripling in the rest of the world by the year 2000 appears to be a minimum commensurate with the life-style aspirations of most people.

If there is to be energy growth, let it be nuclear: the cleanest, safest, and cheapest energy source available for most uses over the next quarter century. Coal and oil, depletable resources, are best reserved for higher-valued chemical products, where the costs of preventing environmental emissions can be better absorbed. Other nations, particularly Germany and Japan, with more severe energy problems than ours, appear thoroughly committed to the nuclear base for future energy growth.

All groups agreed, some reluctantly, that if there was to be energy growth, large nuclear and coal plants would be necessary. Between the two, the evidence seems to point to phasing out coal rather than nuclear as soon as possible.

Will the true "downright Un-American" please stand up! The imposition on the people of the U.S., because they are fallible Homo-sapiens, of Zero Energy Growth or a negative growth rate, by a minority who is sure the people cannot make "right" individual choices, or collective choices by democratic processes appears Orwellian, Hitlerian, and far from the fundamental American tenets of individual liberty constrained only from major injury to the rights of others.

On a worldwide basis, depriving or seeking to deprive other nations of the right to nuclear power benefits deserves a bigger word than Un-American. It is inhuman.

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3. Hammond, R. Phillip, "Nuclear Power Risks," American Scientist, March-April 1974.
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CONCLUSIONS OF THE WORKSHOP

CONCLUSIONS OF THE WORKSHOP

In this section, the workshop group reports have been examined, and the conclusions of each group have been compiled and collected. Preceding each A group set of conclusions, a synopsis of the scenario presented to the group is given along with the energy demands of that scenario. The B groups did not operate with a scenario and were free to approach the question of supply and demand as they saw fit. Following some of the group conclusions, a listing of general items of interest mentioned in the group reports are tabulated below.

Group A-1

Scenario Summary

The general theme characterizing the United States in this portrayal of the future is economic expansion. A general consensus existed in the society supporting economic expansion and industrial growth. Although the society was heavily oriented toward a service economy, "privatism" characterized the economic structure. The supply and consumption of energy were virtually unconstrained.

Scenario Demands

1985	129.5 Q
1995	195 Q

Conclusions

- Scenario requirements of 129.5 Q by 1985 and 195 Q in 1995 made Group A-1 uncomfortable because of the social and economic costs associated with these energy demand figures. Some group members were of the opinion that the U. S. could not use the amount of energy proposed in the scenario even if it were available.
- Group A-1 had detailed data on a lower supply scenario referring to an energy availability of 97 Q by 1985. Even with this lower supply case a number of stresses were identified which

would be greatly exaggerated for the scenario given the group.
These stresses included:

Capital Requirements, e. g. , 5-15% of GNP.

Overloading engineering and scientific communities.

Major relocations of people to sparsely populated areas.

Redirection of oil and gas resources toward selective end-use markets.

Water resource reallocation.

Transportation system expansion--RR, pipelines and electrical transmission.

Foreign trade deficits.

Political problems with other resource-deficient countries.

Items of Interest

- A long lead time is required to build an industrial base for any new technology.

Group A-2

Scenario Summary

The general theme characterizing the United States in this portrayal of the future is represented by increased environmental concern and ecological planning. A general consensus existed in the society supporting a national environmental policy. Further, this solidarity directly affected other social institutions, such as the economy. The consumption and production of energy were significantly constrained in comparison to those levels characterizing the 1960's and 1970's.

Scenario Demands

1985	113 Q
1995	147.5 Q

Majority Conclusions

- With the exception of importation of foreign oil, those energy alternatives which are most attractive from the

point of view of fuel supply are least attractive from an environmental standpoint.

- Even the modest augmentation of fuel supply (113 Q by 1985) required by Scenario 2 will necessitate a major increase in coal production (probably doubling by 1985), greatly increased use of nuclear electric power, exploitation of Alaskan and outer continental shelf oil, and a continuation of foreign oil imports at or above current levels.
- The environmental, social, and economic costs of meeting the Scenario 2 energy demand were considered by all group members to be extremely high and were unacceptable to several members of the group.
- Even to keep energy consumption down to 113 Q's by 1985 will require significant changes in our current energy consumption patterns. Fuel conservation measures totaling about 16 Q's will be required in 1985.
- The 1995 scenario energy supply (138 Q) will require more outer continental shelf oil or oil imports, more coal, in situ oil shale energy plus the commercial introduction of some solar and geothermal supplies.
- Solar energy, particularly for water and space heating, is viewed as a very promising technology for large scale support.

Minority Conclusions

1. The risks associated with nuclear power reactors are too high to be acceptable.
2. One possible method of getting solar technology introduced into the marketplace is to allow electric utilities to go into the business and push it.

Items of Interest

- Positive and negative benefits of conservation tabulated.
- Strong minority report favoring phasing out of nuclear power plants.
- An alternate future of zero energy growth or 2%/year at the most proposed.
- Positive and negative aspects of multinational corporations listed.

Group A-3

Scenario Summary

The portrayal of the future United States represented in this scenario is one characterized by increased governmental planning. The major effort at all levels of government in this society was an expansion of programs to produce equality of educational and economic opportunity. As the goals of these efforts become realized, the demand for energy was increased. This effect results from the positive relationship between socio-economic status and energy consumption.

Scenario Demands

1985	108 Q
1995	145 Q

Conclusions

- Define self-sufficiency as a national goal to change from 20% energy imports down to 5-10% imports by 1990.
- In the 1980's and 1990's there must be a dependence on both atomic and coal fired electric generation.
- There is no overall shortage of energy sources, but there is a serious shortage of available energy to do the kinds of things we want to do where we want to do them.
- In all energy planning, the world energy picture must be considered and not just the U. S. energy picture.
- Broadly based energy R&D will increase the number of future options.

Items of Interest

- Federal R&D policy take heed of regionally specific opportunities.

Group A-4

Scenario Summary

Technological domination and advances characterize this portrayal of the future United States. In a sense this scenario represents most optimistic representation of the future society. Technological advances

were impacting all the social institutions, especially the economy. The efficient production of goods and services are high. The production of energy was more efficient than in the past, and the demand for energy was virtually congruent with the supply.

Scenario Demands

1985	122 Q
1995	152 Q

Conclusions

- The 1985-1995 period is too near term for long-range solutions.
- The group concluded that the future options could be graded as follows in decreasing order of promise:

More domestic energy from conventional sources.

Conservation and efficiency.

Energy redistribution.

Use a pilot plant/systems approach to develop synthetic fuels.

Use a military requirement to develop synthetic fuels through demonstration plant phase.

Develop new domestic sources.

Increased imports.

- Capital requirements of the future total energy picture are so large if synthetic fuels are emphasized as to outweigh consideration of particular strategies.

Items of Interest

- The possibility of climatological change affecting temperature and food production should be considered.
- Energy plans for the United States should recognize the impact of the energy requirements for the rest of the world.
- Mr. Richard B. Ault of Western Airlines presented data on the potential for fuels savings by commercial aircraft speed reduction. This showed substantially smaller fuel savings than indicated in the workshop potential actions. These data will be included in the information data base for this project.

Group A-5

Scenario Summary

The general theme characterizing this representation of the future United States is large scale economic recession. There existed in the early 1980's an inflationary spiral and a breakdown in the international monetary system. "Privatism" continued to characterize the economic structure although some restrictions were placed on the conduct of business. A number of public works projects, including environmental restoration, were initiated during this period to stimulate the economy. This task was all the more difficult owing to scarcities of energy and other resources, as well as significant international competition for them.

Scenario Demands

1985	67 Q
1995	103 Q

Conclusions

- In a depression situation, as defined by the scenario given Group A-5, the following general effects would be expected to prevail:
 - A return to more conservative policies, especially as to consumer spending and investment in capital items.
 - Some significant return to isolationism in international affairs.
 - Significant monetary deflation in the short run, and possibly long term, unless deficit spending is overdone.
 - Minimum international trade as a result of the failure of international monetary policies.
- Defined adequate supply in 1985 as 90 Q.
- Support energy expansion in low-risk areas such as coal (with stack gas scrubbing), coal gasification and liquifaction, shale oil and nuclear.
- Development costs and future capital investments for future energy requirements will be high.

- The suggested approaches to increasing energy will result in a broad range of acceptable fuels and will not have a unique impact on aviation or other transportation modes.

Items of Interest

- Regionalism will be a problem in dealing with future energy problems.

Group A-6

Scenario Summary

The general theme characterizing this portrayal of future United States is international disarray. The economic and political policies discussed in this scenario resulted in the assumption by the United States of an increasingly isolationist stance in the 1980's and 1990's. The United States Middle East policy was an ambiguous one aimed at placating the Arabs and Israelis while pleasing neither. Accordingly the Arabs again utilized an oil boycott to influence world opinion with the result that the United States placed primary importance on the domestic development of energy. Diverse production strategies were employed by this country in an attempt to meet the demand for energy.

Scenario Demands

1985	106 Q
1995	139 Q

Conclusions

- There is a need for a mix of potential actions because of social, economic, political and technical forces.
- Inform the public and institutional decision makers.
- There is a lack of comparative knowledge about alternative mixes, especially about risks and returns, even among technical experts.
- There is a divergence of values among various social groups.
- The central issues are political.
- Current decisions by U. S. and other governments have long-range political consequences.

Items of Interest

- Must increase rapidity with which regulatory agencies deal with emerging issues.
- Evidence from social psychology strongly indicates that citizens pay attention to information only on those issues in which they are interested.
- Evidence that most people selectively perceive and selectively retain only that new information which agrees with their pre-conceived beliefs and already held values.
- Politicians and lobbyists interact only when they already agree with each other.
- Decision-makers usually listen to those groups which can help get them reelected.
- Need to insure that negative results won't kill the project.
- How do we insure that positive results will have an impact on future policy?
- How do we know how generalizable the experimental results are?

Group B-1

Conclusions

- Begin conservation efforts now and continue into the future.
- Increase near-term production of primary energy (oil, natural gas, conventional nuclear and coal); for the long term effort develop solar, fusion nuclear, etc.
- Initiate efforts in coal based synthetic gas and liquids.
- Maintain oil and gas imports at <15% of total energy consumption.
- An energy supply sufficient to satisfy an energy demand growth rate of 2.3% per year is considered adequate for the 1980's and 1990's.
- Based on the conclusion above, the consumption of energy is projected to be 100 Q's for 1985 and 125 Q's for 1995. The transportation sector would require 25 Q's for 1985 and 28 Q's for 1995.

- Based on the two statements above, it is concluded that the transportation requirement could be met by diverting petroleum from some nontransportation uses where substitution of other fuels is possible.
- The electric automobile is beyond the 1990 time frame.

Group B-2

Conclusions

- The demand for energy by 1985 will be in the 105-120 Q range; lower than most projections.
- For the 1980's and 1990's heavy short-term reliance must be placed on coal, nuclear energy, oil imports and conservation, with phase in of "clean" technologies (solar, geothermal, synthetics with environmental control).
- Conservation is the single most promising strategy for the U. S. in both the long and short term.
- Unique cooperation between public and private sector must be established.
- The most promising actions for assuring supply through 1985 are judged to be:

Double coal production - 15 Q addition.

Build nuclear plants now "in the piping" - 17 Q addition; but phase out in the 1990's as "clean" technologies fill gap.

Search for and develop geothermal resources - 1 Q addition.

Recycle solid wastes - 2 Q addition.

Nearly double hydroelectric capacity - 2 Q addition.

Increase imports of oil, natural gas, processed materials, petrochemicals and electricity.

Keep even on production of domestic oil and natural gas.

- The most promising possibilities for supplying energies in the 1990's are:

Solar energy. An implemented technology has the potential for replacing heating, cooling and hot water loads for

domestic and commercial sectors; those loads currently consume about 20% of the nation's energy. The nonpolluting, inexhaustible nature of solar energy makes it particularly attractive.

Geothermal electrical energy.

Solar/biological and solar/wind technologies.

The output of research and development not yet performed.

Development of new innovative transportation infrastructure which will be necessary for materials transportation of coal.

The capital expenditures required for energy expenditures can be handled if there is U. S. government support during initial, more risky stages.

Items of Interest

- The group felt uncertain about the social and political results of obvious energy conserving options that would have an impact on life style.
- Credibility of national energy and energy resource data base in doubt.
- An open attempt to understand and take into account the differing political objectives and value systems of trading partners of the U. S. should be an objective of an integrated energy policy.
- Areas where legal processes could streamline energy decisions:

Power Plant Siting: A national land use act which would encourage and help finance state and regional land use plans would shift the burden of power plant siting from private utilities to public bodies where it belongs.

Consolidate departments with overlapping jurisdictions to assist in better decision-making.

Streamline court procedures.

1) Provide for expedited hearings.

2) Set time limits on bringing suits, together with wide publicity.

Consider private property right/police power tradeoffs.

- Group B-2 asks how to measure the socio-economic costs of not pursuing a vigorous coal/nuclear strategy.

Group B-3

See Group A-3 above.

Group B-4

Conclusions

- The group decided to work toward a "Plausible Desirable Scenario" using a 3.5 to 3.7% growth in GNP to 1985 and 1995, respectively.
- An increase in energy efficiency and conservation was projected for 1985 and 1995 leading to a requirement of 106 Q in 1985 and 145 Q for 1995.
- From present oil and gas fields the 1974 level of production can be maintained based on accelerated development and increased recoveries, principally as a result of improved economics.
- Despite the large capital outlays required for energy development, they can be easily absorbed by the capital market between the present and 1995. The utility companies, however, face a unique financing problem.
- There are two alternative approaches to the problems and risks inherent in the shortfall:

Develop additional new domestic supplies to avoid the necessity of importation.

Develop new high technology products which can be transformed into exports.

Items of Interest

- Mr. Wilson Harwood of SRI made an oral presentation and compiled notes entitled "Importation of Oil and the Arab's Oil Policy". These notes are included in Section 4 above.
- Dr. Arnold Goldburg of Boeing submitted a booklet prepared by his company entitled "Transportation Systems Analysis and Energy Comparison". This booklet will be included in the information data base for this project.

Group B-5

Conclusions

- Energy self-sufficiency for the U. S. should be defined as allowing 5% petroleum imports.
- If the U. S. continues present rate of growth with no positive energy plan in effect, there is no assurance of adequate portable energy fuel.
- A portable energy shortage will have adverse social consequences in the U. S.
- The lack of proper energy planning and subsequent implementation can lead to hostility among the free world and the developing countries.
- Expand use of available proven and inferred reserves in the next two decades, e. g., Alaska, outer continental shelf, secondary and tertiary recovery, increased coal production.
- The U. S. should plan toward an energy requirement of 112 Q in the year 2000.
- Actions in the following areas are required:

Conservation

All-out coal production ASAP with environmental control

Plan now to introduce coal liquifaction processes by the 1990's.

Institute a nuclear program now to furnish 30 Q by 2000.

Develop solar, geothermal, etc. ASAP.

Promote electric mass transportation by the 1990's.

Energy form substitutions.

Change social/business forms of personal contact-communications.

- Shortfall in energy by the year 2000 will be about 30 Q.

Items of Interest

- Development of western coal/shale requires scarce water.
- Breeder reactor development should continue without commitment to deploy.

- A model was used to define the portable fuel requirements for 1980, 1990 and 2000.
- Group B-5 developed a scenario for the future including a desired set of conditions for 1985 and these conditions then defined some requirements of a national energy policy.

Group B-6

Conclusions

- The only domestic energy sources with sufficient potential to maintain the nation in its historic growth pattern are strip-mined coal and nuclear fission.
- If we forego the use of either of these energy resources, we will enter a period of negative per capita energy consumption.
- We do not believe there is an adequate data base from which to construct a picture of our society under negative per capita energy consumption. We, therefore, cannot rationally decide on whether to accept nuclear risk or a restructured society stemming from negative per capita energy consumption.
- We conclude that the Middle East is not a feasible source of sufficient energy to allow us to escape a decision on alternatives mentioned immediately above.
- We need a reliable analysis of the social consequences of negative per capita consumption and suggest that reliability may be increased by including talent that reflects experience with a variety of societies and cultures.
- A no-waste ethic induced by government, would facilitate a better understanding of what we will be up against in using conservation as an energy-saving tactic in industry and smaller and individual units.
- Small cars are more promising for fuel conservation than more efficient internal combustion engines.
- Electric vehicles are expensive, not fuel saving from a total energy use analysis and their impact would be small by the year 2000.
- General industrial fuel requirements per unit output can be reduced about 20-30% by the 1990's.
- A no-waste national policy and ethic could yield a potential savings in energy of eight million barrels per day by the 1990's.

Items of Interest

- A minority report called for a moratorium on all further construction of nuclear fission plants.

A Summary of Workshop Conclusions

It seems appropriate to begin this summary by restating one of the conclusions of Group A-3:

"There is no overall shortage of energy sources, but there is a serious shortage of available energy to do the kinds of things we want to do where we want to do them. "

There was considerable commonality in the conclusions of the workshop groups. This even was true in the A groups where each one used a different future scenario.

Perhaps the most important general conclusion that can be inferred from the workshop group reports is that there is no magic answer to our future energy problems and requirements. No simple or rapid social, economic, technical or political answer was proposed.

A second general conclusion seemed to be that most of the participants believed that the historical energy growth rate in the United States must decrease. This conclusion brought forth considerable personal and group concern for the social, economic, financial and international impact of any energy decision.

A third general conclusion resulting from the second is that conservation will have more immediate impact than any other action, and it is absolutely essential, of course, if a decrease in the historical U. S. energy growth is to be achieved. Conservation must be achieved by multiple methods beginning with public ethics and mores through legislative, technical and financial actions.

Even with successful conservation efforts, a fourth general conclusion of the workshop seemed to be that the U. S. will have to further expand its present energy sources. This expansion must include staying even with the present domestic petroleum and gaseous hydrocarbon supply through additional drilling and secondary and tertiary recovery.

Development of new resources on the outer continental shelf, both east and west coast, and Alaska, plus full exploitation of the Alaskan north slope, must be accomplished. Increase in the use of coal is necessary even if some relaxation of EPA standards on an individual and limited basis is required. Even nuclear power generation must continue and be speeded up for the next 10 or 20 years at least.

The conclusion that technical programs should be started now even though their impact probably would not be felt until the 1990's was a general one. One requirement was that technical programs should be multipronged and deal with a number of possible energy options since it was expected that a certain number of failures would be experienced in such a broad technical effort.

Finally, it was generally concluded that there is a need for a national energy policy that was both understood and acceptable by the general public.

RECOMMENDATIONS OF THE WORKSHOP

RECOMMENDATIONS OF THE WORKSHOP

The workshop participant group reports have been examined, and the recommendations of each group have been compiled and collected. This compilation is given below starting with the A group recommendations in numerical order and then followed by the B group recommendations in a similar fashion.

Group A-1

- Crash R&D programs for development of technology for utilization of various energy sources.
- Break traditional R&D patterns and assist implementation by new legal, managerial and institutional structures/interfaces.

Group A-2

Majority Recommendations

- Plan now for low energy growth in the 1990's.
- Initiate immediate and early cooperative heavy private and public R&D for development of technology for clean energy sources (solar, wind, geothermal).
- Use solid wastes for energy production.
- Achieve 17 Q conservation savings in 1985 under National Petroleum Council projections by:

Increasing average m. p. g. of auto fleet from 13 to 26.

Residential and commercial conservation.

Improve industrial process efficiencies.

- Reach 138 Q in 1995 without increase of nuclear electrical energy above 1985 level.
- Deregulate natural gas prices.
- Have full cost pricing of all energy forms.
- Provide government subsidies for emerging conserving technologies.

- Initiate broad scale public and private efforts through information and education to change U. S. ethic concerning energy and material use to "no-waste" ethic.

Minority Recommendations

- Place an immediate moratorium on future expansion of the nuclear power industry substituting stronger conservation measures and reliance on oil imports and coal.

Group A-3

- Amend environmental protection law to allow more time for full implementation of clean air standards.
- Establish floor under the price of imported energy to allow competitive domestic sources to be developed. Stabilize the floor for 25 years.
- Federal government to be a major participant in cost sharing to develop means for insuring that new technology goes from research to commercial status.
- Assure adequate domestic uranium supplies and enrichment and fuel cycle facilities for self-sufficiency.
- Deregulate wellhead price on new natural gas.
- Government address the problem of obtaining capital for significant increase in electricity, coal, nuclear capacity.
- Create eminent domain for coal slurry pipelines.
- National needs take precedence over states rights in energy matters.
- Establish priority uses for natural gas as follows: (1) selected petrochemical, (2) residential, (3) commercial, and (4) other.
- Auto manufacturing or import to U. S. should achieve 20 mpg after 197X (through taxes on horsepower, weight, etc?).
- Relax NO_x standards to 2 gm/mi.
- Speed implementation of electrified mass transit systems in urban areas.
- Prevent institutional interests from blocking efficient transportation, i. e. , ICC or CAB (e. g. , cheapest truck route from Detroit to Los Angeles is through Atlanta).

- Government impose standards for minimizing energy losses in commercial and residential new construction.
- Federal government specify land and water use planning on state or regional basis to be more cognizant of energy requirements.
- Federal government lead development of electric car.
- Accelerate R&D on nuclear waste.
- Accelerate R&D on sulfur/sulfur dioxide removal to accelerate coal usage.
- Combine FEA/ERDA into Department of Natural Resources with cabinet level secretary and provide priorities for necessary R&D.
- Communication usage and improvement should be investigated as an alternate to transportation.

Group A-4

- Recommend a pilot plant/systems approach for synthetic fuels development. The word systems here implies a total examination of all energy required in a synthetic fuels operation from mine to user.
- Full scale synthetic fuel demonstration system should be conducted in conjunction with a military requirement.

Group A-5

- Carry out increased energy supply in private sector as much as possible with government action to reduce investment risk and thus lower acceptable return on investment plus price control, if required.
- Relax environmental constraints/near term.
- Public education regarding a finite world.
- Programs at public expense which pay for dislocation or unfairness and deal fairly with those who will be penalized for changes made in the national interest.

Group A-6

- Create better communication among sources of knowledge, the public and decision-makers. (Need an objective, respected source to get facts to the public.)
- Create appropriately chosen task forces to legitimize and publicize potential actions.
- Conduct social experimentation concurrently with demonstration and pilot projects.

Group B-1

- Four major strategies should be pursued to achieve the desired supply of 100 Q's in 1985 and 125 Q's in 1995.

Conservation

Increase production of primary energy

Development of synthetic fuels

Limit imports to less than 15% of the total supply.

- Conservation recommendations

Automotive transportation.

- 1) Mandatory use of steel belted radial tires
- 2) Reduce vehicle weight
- 3) Reduce engine displacement
- 4) Improve coupling of engine to drive wheels.

Air transportation

- 1) Improve load factors
- 2) Improve scheduling from fuel consumption standpoint
- 3) Eliminate short hauls
- 4) Increase energy efficiencies (aerodynamics and propulsion).

Intermodal transfer

- 1) Try to shift freight to more economic modes
- 2) Try to develop more uniform state regulations.

Residential and commercial buildings

- 1) Improved insulation
- 2) Low heat loss structure design
- 3) Use total energy systems.

- Increased production of primary energy.

Explore and develop offshore deposits

Investigate improved secondary and tertiary recovery methods

Develop advanced fracturing techniques

Expand conventional nuclear capacity

Expand coal production

Important longer term sources include:

- 1) Breeder reactors
- 2) Solar energy
- 3) Oil shale/tar sands.

These items require immediate substantial research and development.

- 1) Relax air standards to increase coal usage in the near term.

- Development of synthetic fuels. Concentrate on processes under development such as coal gasification, liquifaction and synthetic gas.

Group B-2

- Many technical approaches could end in failure, and, therefore, research money should be widely spread among a variety of more promising strategies to allow selection of viable options.

- Streamline governmental processes for licensing nuclear plants.
- Develop independent audit procedures to check closely on agency performance of waste management and security procedures to ensure uniformly responsible handling of dangerous materials from nuclear plants.
- Arrange means for swift international technical transfer so that the nation can benefit quickly from technology used in other countries (e. g. , German mining technology).
- Begin training of adequate numbers of highly skilled personnel necessary for developing and applying new technologies (especially by creation of new mining schools). Use government subsidies, guaranteed jobs in government for graduates and fellowships at the National Laboratories as reservoirs for pools of talent which the nation will need quickly.
- Make certain that supportive technologies such as high-temperature, high-pressure valves are in existence as needed.
- Provide leadership and incentives (or potentially, elimination of disincentives) to the transportation industry in general and railroads especially to meet the national need for coal transportation.
- Make a national effort to check the data base for the summary information on oil, gas, nuclear, geothermal and coal resources of the nation. Concentrate on taking the baseline data itself.

Group B-3

See Group A-3 above.

Group B-4

- To bring in additional conventional domestic energy sources in 1985 and 1995, the following factors must be present:

Positive incentives must be maintained for industry and finance.

Perception by the public must be accomplished, which probably requires improved communication techniques between the decision-makers, technologists and the public.

This perception includes cost effective adjudication of the environmental issues.

The Alaska Gulf and the Atlantic Coast exploitation require changes in laws and/or regulations. In this regard, on the Atlantic Coast, the local political problems must be resolved. The development of the Alaska Gulf requires utilization of advanced production technology.

The further development of the North Slope requires further exploration and increased pipeline capacity.

To accomplish the coal option requires surmounting the supply problems in equipment, transportation, skilled mine labor, and the socio-environmental issues involved in setting up new mining communities, as well as the requirements for uniform air and water quality standards across political boundaries.

To accomplish the nuclear option requires the removal of conditions which might motivate utility decisions to delay or suspend nuclear expansion plans. These include a possible continuation of current financial stringencies and siting and environmental delays, uncertainties regarding the timely availability of fuel cycle facilities for conventional reactors, including enrichment, reprocessing and waste disposal, and uncertainties regarding the economic feasibility of breeder systems.

- Develop new additional domestic supplies of energy by funding pilot plant demonstrations of about 1/10th full scale.
- Use heavy involvement of industry in pilot plant activities to provide a continuity to full scale plants.
- NASA should continue to lead and expand its efforts to develop new aeronautical products, including energy conserving aircraft, to help maintain a viable position in the world market place.

Group B-5

- Fiscal support of energy activities should be limited to $\leq 15\%$ of the GNP to allow pursuit of other national objectives.

- Recommend an energy policy which contains elements of the following strategy:

Provide conservation of general energy usage.

Point immediately toward all-out coal production while simultaneously controlling environmental insult.

Institute a nuclear power program with up to 30Q by the year 2000.

Develop solar, geothermal and other power sources where feasible.

In the area of portable energy:

- 1) Utilize electric/battery vehicles in urban, transit by mid-1990's.
- 2) Promote urban electric mass transit.
- 3) Develop efficient intermodal mass transport on a systems basis.
- 4) Promote lightweight and low horsepower aircraft and ground transport vehicles.

Implementation of this suggested strategy must have strong government leadership in the areas of energy planning, financial support, risk participation, public education and broadly based energy R&D programs.

Group B-6

- An R&D program is recommended to develop technology for use of the large heat loss from electric power plants for space and water heating.
- A penetrating study is needed to determine the social and economic impact of a low or negative energy growth.

A Summary of Workshop Recommendations

The recommendations of the workshop groups can be readily be classified into the following six categories:

Conservation

Increase Production of Primary Energy Sources

Limit Imports

Develop Synthetic Fuels

Develop New Energy Sources

Transportation Alternatives

One characteristic was prevalent throughout the recommendations of the workshop groups, and this can best be described as a concern for the total system as it relates to energy problems and requirements. In this context the total system is not just limited to hardware or plant configuration but is better described as including the social, political, economic and international elements as well as the technology of the situation. As described below, multipronged, intense, even crash research and development technology programs are recommended, but these programs are not recommended to operate in a vacuum. Important program recommendations in nontechnological areas also were made.

General summaries of the workshop recommendations according to the six headings listed above are as follows:

Conservation

- Automotive Transportation

- Mandatory use of steel belted radial tires.

- Reduce average vehicle weight in U. S. automobiles.

- Reduce engine displacement.

- Improve coupling of engine to drive wheels.

- Amend Clean Air Act to allow more time for full implementation of standards.

- Relax NO_x standards to 2 gm/mi.

- Promote lightweight ground transportation vehicles.

- Air Transportation

- Improve load factors.

- Improve scheduling from fuel consumption standpoint.

Eliminate short hauls.

Develop energy conserving aircraft.

- Residential and Commercial

Develop low heat loss structure.

Use total energy systems.

Develop improved insulation or insulation techniques.

Government standards for minimizing energy losses in new construction.

- Industrial

Improve thermal efficiencies of industrial processes.

Develop technology for use of the large heat loss from electric power plants for space and water heating.

- Social, Political, Legislative

Need an objective respected source to get facts to the public.

Educate the public regarding a finite world ("no waste" ethic).

Plan now on low-energy growth in the 1990's.

Government subsidies for emerging conserving technologies.

Public and private efforts through information and education to change U. S. ethic concerning energy and material use.

Establish priority uses for natural gas.

Increase Production of Primary Energy Sources

- Petroleum

Explore and develop offshore deposits.

Improve secondary and tertiary recovery methods.

- Natural Gas

- Explore and develop offshore deposits.

- Develop advanced fracturing techniques.

- Deregulate natural gas prices.

- Coal

- Expand coal production.

- Relax air standards to increase coal usage in the near term.

- Create eminent domain for coal slurry pipelines.

- Accelerate R&D on sulfur/sulfur dioxide removal to increase coal usage.

- Atomic Energy

- Expand conventional nuclear capacity.

- Continue development of breeder reactors.

- Streamline governmental processes for licensing nuclear plants.

- Develop independent audit procedures for waste management and security to ensure uniformly responsible handling of dangerous materials from nuclear plants.

- Assure adequate domestic uranium supplies and enrichment and fuel cycle facilities

- Accelerate R&D on nuclear wastes.

- Determine "socio-economic cost" of not pursuing all-out nuclear power program through the 1990's.

- Social, Political, Legislative

- Make national effort to obtain reliable baseline data on oil, gas, nuclear, geothermal and coal resources of the U. S.

- Train skilled personnel.

- Arrange for swift transfer of international technology.

- National needs to take precedence over states rights in energy matters.

Improve transportation system for coal.

Assure capital availability for coal and nuclear expansion.

Limit fiscal support of energy activities to $\leq 15\%$ of the GNP to allow pursuit of other national objectives.

Limit Imports

- Limit imports to less than 15% of total energy supply.
- Establish floor under the price of imported energy to allow competitive domestic sources to be developed.

Develop Synthetic Fuels

- Concentrate on processes under development such as synthetic natural gas and coal gasification and liquifaction.
- Assume technical failures will occur, and, therefore, research money should be widely spread among a variety of more promising strategies.
- Make certain that supportive technologies such as high-temperature, high-pressure valves are in existence as needed.
- Federal government to share cost and develop means for insuring that new technology goes from research to commercial status.
- Use a pilot plant systems approach for synthetic fuels development.
- Arrange a full-scale synthetic fuel demonstration system in conjunction with a military requirement.

Develop New Energy Sources

- Implement strong solar energy research and technology program.
- Initiate substantial technology programs in the use of oil shale and tar sands.
- Use solid wastes for energy production.
- Expand exploration and development of geothermal energy sources.

Transportation Alternatives

- Shift freight to more economic modes.
- Develop more uniform state regulations.
- Speed implementation of electrified mass transit systems in urban areas.
- Prevent institutional and agency interests from blocking efficient transportation of passengers and freight.
- Federal government lead development of electric car.
- Communication usage and improvement should be investigated as an alternate to transportation.
- Develop efficient intermodal mass transport on a systems basis.
- Utilize electric/battery vehicles in urban transit by mid-1990's.

DIRECTIONS FOR NEAR TERM ACTIONS

DIRECTIONS FOR NEAR TERM ACTIONS

An Interpretation of Workshop Results

The mix of participants at the Portable Fuels Workshop were chosen from a wide variety of disciplines, backgrounds and experience in order that a broad view of the situation regarding portable fuels in the 1980's and 1990's would be obtained. The workshop thus attempted to examine all elements relating to portable fuel futures including social, political, economic and international factors as well as technical needs and opportunities. Because of the diverse backgrounds of the participants and the short intense period of the workshop activity, it was impossible to attempt to detail specific recommendations; the development of future program plans and schedules was not attempted. It is the responsibility of the NASA contractors, TRW Systems and the University of Texas, to independently review and analyze the results, conclusions and recommendations of the workshop for the purpose of identifying those issues requiring and justifying detailed definition and program plan development.

In a broad sense the workshop did conclude that there certainly would be a continuation of the energy problem in the United States at least into the next century. Portable fuels, being a significant portion of the energy requirements, and presently being an inefficient user of energy, also will have problems of supply and change during this same time period.

The previous two sections have summarized the written conclusions and recommendations of the workshop groups, and these results of the workshop will be analyzed in detail. From an overall viewpoint there were several guiding principles and broad directions that came out of the conference. Two principles were stressed repeatedly:

- We are not sure of any specific approach, and therefore, a multipronged concurrent effort must be made.
- Consider all elements, both societal and technical, from the very beginning of any program.

Similarly, a priority of overall directions came out of the workshop deliberations:

- Conserve what we have. Conservation will be absolutely necessary, and the impact and requirements will be significant.
- Exploit our present and known resources. There is no near-term substitute for petroleum, natural gas, coal and uranium (nuclear).
- Develop new energy sources. Continue efforts on synthetic fuels from coal and breeder reactors and open and expand programs in solar energy, waste conversion, geothermal, etc. In particular, open opportunities for new ideas through basic research.
- Change and substitute. This direction offers opportunities for more efficient uses of our energy and material resources.

The specifics summarized in the previous two sections will be analyzed in light of the principles and directions just described.

3. PHILOSOPHY OF PROBLEM STATEMENT DEVELOPMENT

3. PHILOSOPHY OF PROBLEM STATEMENT DEVELOPMENT

The product of a multidisciplinary workshop would be expected to be a series of very broadly defined conclusions and recommendations, and this is what resulted from the Monterey sessions. In the time available and within the methodology used, there was very little discussion of detailed technical and/or social/economic/political factors important to each conclusion or recommendation. The Monterey workshop did produce very clear, broad directions and described important factors from various disciplines that should be considered in any program related to portable fuels.

Another characteristic of the conclusions, recommendations and directions was that they were not necessarily new or unique. With all of the attention that energy questions, problems and ideas are receiving from all segments of our society, it is hardly to be expected that completely unique proposals would result. Nevertheless, within the broad directions proposed by the participants at Monterey, a number of programs can be defined that are important to the portable energy future of the United States.

TRW's approach to the selection and development of specific problem statements based on the Monterey workshop results considered the following factors. First, a general examination was made to determine the types of programs that were already under way. In this examination attempts were made to consider legislative and political activities as well as technical projects. For this purpose the data base developed in this project was a prime source of information and preliminary conclusions were discussed with knowledgeable people at NASA, The University of Texas at Austin and within TRW's Systems and Energy. Finally, telephone discussions were held with workshop participants to obtain the advantage of their expertise. The first step thus divided the workshop recommendations into two categories, namely, those where programs already were under way on some identifiable and significant level and those recommendations where no program(s) could be identified.

Where program(s) were determined to be under way, an effort was made to determine if a related area might require some activity or if a new approach or idea could be identified. If such a situation could be

identified, then further consideration of a problem statement was given. It should be clearly understood that these activities were of a cursory nature within the time and funding constraints of this project.

A list of recommendations for possible problem statement development resulted from the approach just described. The variety of recommendations from the Monterey workshop allowed a latitude in selecting an area for specific examination. In selecting an area for further evaluation, the capabilities and responsibilities of the National Aeronautics and Space Administration were the prime consideration. These capabilities and responsibilities were of three general types:

- 1) NASA has responsibility in aeronautical engineering development for the public benefit
- 2) NASA has sponsored work in a number of advanced technology areas.
- 3) As a result of experience in the space program, NASA has a capability in examining a total system. The activities of the sponsors of this program, the Systems Studies Division of the NASA Ames Research Center, is one evidence of this capability. The final problem statements described in subsequent sections attempt to reflect at least one of the NASA capabilities and responsibilities described above.

4. DEVELOPMENT OF PROBLEM STATEMENTS FROM WORKSHOP PARTICIPANT RECOMMENDATIONS

4. DEVELOPMENT OF PROBLEM STATEMENTS FROM WORKSHOP PARTICIPANT RECOMMENDATIONS

The conclusions and recommendations of the work groups at the Monterey workshop (Section 2.3) and the philosophy of work statement development (Section 3) were used as a basis for problem statement development. The first step was to give each candidate statement a title which reflected both the broad subject area and the more specific categories under investigation. It should be understood that at this point the workshop conclusions and recommendations are being interpreted, combined and more specifically directed by TRW personnel.

For convenience in cataloging the candidate problem statements, they were divided into four areas corresponding to the general objectives defined by the workshop. These are:

- Conserve what we have
- Exploit our present and known resources
- Develop new energy sources
- Miscellaneous.

This exercise led to the general description of 47 candidate statements; these were examined in more detail through searches of the project data base, evaluation by knowledgeable people at TRW's Systems and Energy discussions with out colleagues at NASA/Ames Research Center and the University of Texas at Austin, and occasional telephone discussions with workshop participants. Twenty-nine candidate statements were eliminated because programs are already under way. The process of elimination is described in the following sections.

4.1 CONSERVE WHAT WE HAVE

4.1.1 Teach the Public the Economics of Automobile Operation

This subject area was examined because it was felt by the workshop participants that the general public really did not have a firm idea of the cost of operating an automobile. The general public is already bombarded with mileage claim advertising from automobile manufacturers and conservation ideas from automobile clubs and tire manufacturers. The Environmental Protection Agency already runs mileage tests on automobiles sold

in the United States and publishes this information. In considering this general question no reasonable educational program for automobile operation economics was conceived. Such an activity would be a massive effort well beyond the scope of this program and perhaps even beyond the capabilities of the Federal Government.

One comment made at the workshop was that the young people will have to live with automobile conservation all of their lives. This led to the consideration of an educational program directed toward and operated by young people. Many high schools and junior colleges offer courses in automobile maintenance and repair leading to the training of the students as auto mechanics. It was felt that this particular group of young people operating within their school could learn the economics of automobile operation and could bring this information to their fellow students.

A program idea was conceived in which a high school or junior college would act as a "contractor" and involve their students in the automotive mechanic courses. These students would develop a program to determine the influence of driving and maintenance habits on gasoline consumption. They would use both their own cars and enroll their fellow students in the program. It is not proposed that car maintenance by the school for the students' benefit would be involved. The students could develop their results using car weight and horsepower as a criteria and not evaluate the results on the basis of the make or model of the automobile. It was envisioned that the auto mechanic students would develop their own reports and hopefully would announce their results in the local community through speaking at service clubs or on local radio or TV. It was felt that the students would have credibility with their peers and even with older members of the community. A second step in such a program might involve the automotive mechanic students in engine modifications for better mileage. Again, they could report their results as above, using generic descriptions and not company identifications.

In conversations with personnel at NASA Ames it was determined that this NASA center had a work enhancement program with several local junior colleges. Similar programs also exist at other NASA centers. It is believed that the introduction of such an automobile operation program into NASA's work enhancement program would be valuable not only to the

students, but to the local community. Since the implementation of this concept would best be performed within existing arrangements, no problem statement will be written, but it is recommended that NASA Ames further explore the idea with the local junior colleges with whom they are presently involved.

4.1.2 Investigate the Potential for Fuel Conservation in Aircraft Operations

In this subject area attention was directed primarily to fuel conservation opportunities in commercial air transportation. A very basic study in this field was performed by the Rand Corporation for the National Science Foundation (00712E). Since the publication of the Rand report in October 1973, the Arab oil boycott has speeded up energy conservation efforts by the air transportation industry. It was found that aircraft manufacturers commonly advised their customers on the operation-fuel consumption pattern of the aircraft. One airline has developed an air transport fuel management program which has proven successful, and the program has been sold to a number of domestic and foreign airlines.

At this time the Civil Aeronautics Board and the airline industry are attempting to improve the fuel economy of airline operations by increasing load factors by various techniques. Aircraft cruising speeds are being reduced to a small degree in order to reduce fuel consumption.

Particular attention was paid to aircraft delays related to the terminal area and landing and takeoff. Obviously the fuel consumption of the air transport industry would be decreased if airplanes did not have to wait in line to take off, did not have landing delays at their destination, and if some of the engines were turned off immediately after landing. It was found that the Federal Aviation Administration, the air transport industry and airport operators are proceeding to reduce fuel consumption by decreasing these delays. This is a continual process of improvement particularly by the Federal Aviation Administration in its control of aircraft movement in the national air space. As might be expected, the requirements for control centers covering aircraft movements are becoming more and more complicated, and their complexity will increase as continual efforts are made to better control aircraft movement for fuel conservation purposes.

In recent times another cause of air traffic delays has been wake vortex resulting from the flight path of the new wide-bodied jet aircraft. This vortex or air turbulence lasts for several minutes and constitutes a danger to other aircraft, particularly lighter ones, following the path of wide-bodied jets. Air frame configurations decreasing the intensity of this vortex would improve air traffic control and increase fuel conservation. NASA has programs under way directed toward solutions to this problem.

4.1.3 Investigation of the Potential for Fuel Conservation in Automotive Operations

Due to the private use of automobiles in the United States, this was a prime area for examination of fuel economy operations (00700E, 00685E, 00684E and 00683E). Four major areas are available for reducing the fuel consumption of automobiles. The first, of course, is to reduce and enforce lower speed limits. The 55 mph speed limit now applies throughout the United States, although, of course, its enforcement probably varies considerably.

A second approach would be to lower the average weight of automobiles since it is well known that the gas consumption is significantly influenced by the automobile weight. At the present time average car weights are being reduced primarily due to economic factors which have priced heavier automobiles out of the reach of the average citizen. Legislative action to speed the reduction of automobile weights is another possibility. It is felt that the basic information upon which to base legislation is available.

A third approach to decreasing gasoline consumption is through a change in the automobile engine. This approach is always under general examination by the automotive industry, and sometimes their evaluation becomes a major program as occurred within the last few years when the U.S. automobile companies studied the rotary engine. The Environmental Protection Agency has a program to examine a number of power plants for automotive application. Studies of the type recorded in the above references would indicate that any automotive power plant change would be very

slow in its introduction to general use and, further, that the probable number of options where real fuel consumption savings can be achieved are not large.

A fourth area where fuel conservation can be obtained is in accessories and subassemblies as, for example, steel belted radial tires non-idling systems, catalytic converter improvements, etc. The examination of this area did not identify any activities justifying the preparation of a problem statement on this project.

4.1.4 Develop Energy-Efficient Aircraft

This recommendation from the workshop was directed toward consideration of reducing fuel consumption either through air frame redesign or engine development or both. NASA presently has programs directed toward this objective, and these programs have both NASA in-house elements as well as contracts with large aircraft manufacturers. Therefore, no problem statements were developed in this area.

4.1.5 Develop New Lightweight but Strong Materials of Construction for Aircraft and Engines

There was a workshop recommendation that strong emphasis should be placed on investigating and evaluating all materials of construction with emphasis on high strength-to-weight ratios. This idea, of course, is based on the fact that lightweight vehicles consume less fuel. As part of their energy-efficient aircraft programs, NASA has this question as one important element of the programs. Further, it is known that other government agencies, such as the Air Force Materials Laboratory and various aircraft manufacturers, are constantly examining materials of construction. Therefore, no problem statements have been written in this subject area.

4.1.6 Examine the U.S. Transportation System in Light of Energy Requirements

This subject area is a composite of several recommendations from the workshop relating to the impact of federal government agency rules, federal and state taxes and state regulations on energy consumption in the U.S. transportation system. In particular, recommendations were made at the workshop that the rules of such agencies as the Interstate Commerce

Commission, Federal Aviation Administration, Civil Aeronautics Board, Maritime Commission and the Corps of Engineers be studied to particularly identify rules that increase energy consumption.

NASA Ames has issued a request for proposal and is now evaluating responses and selecting contractors for a joint NASA/DOT transportation technology assessment effort in 1975. Since that study is expected to cover this subject area, no problem statements were developed here.

4.1.7 Develop Federal Standards for Residential and Commercial Building Insulation

The amount of energy used for heating and cooling of residential and commercial buildings can be decreased through the use of additional insulation. Although the building industry is one of the largest in the U.S., its infrastructure is very fragmented. Codes and zoning requirements vary considerably throughout the United States with particular regard to insulation requirements. The only unifying force available is the Federal Government and, particularly, the Federal Housing Administration, a part of the Department of Housing and Urban Development. The FHA in recent months has changed their minimum property standards to permit the use of additional insulation so that the additional cost can be handled by the FHA Guaranteed Mortgage. Although the FHA action is significant, there are a large number of structures financed by conventional mortgages and other debt arrangements.

According to the Congressional Research Service Energy Conservation Issue, Brief Number ib 74054, several bills have been introduced into the Senate, all or portions of which are directed toward better insulation standards. A further investigation of this question was conducted to determine if the technical and economic information required to set standards was available. It is believed that sufficient information on the thermal and physical properties of common and reasonably priced insulation materials is sufficiently well-known. Data to compare the finished cost against the life cycle savings also are available. An examination was made of the question of evaluating flammability and fire retardancy of insulation. This area seems to be sufficiently well understood to permit the development of standards.

Although the Congress has not yet passed an energy conservation bill involving insulation standards, no problem statement in this area was developed since it was concluded that the technical and economic information to support such legal action is available.

4.1.8 Substitute Communication for Transportation

Energy devoted to the movement of people for the purpose of individual discussions, meetings and conferences could be decreased by the increased use of communication devices. Certainly within the United States at the present time the telephone substitutes for trips and/or letters in many situations previously handled by personal contact. Generally this substitution is limited to contacts between two people with occasional use of conference calls where additional individuals are involved. It certainly is within the capabilities of present technology to handle larger conferences and meetings by audiovisual devices. These would be energy-saving mechanisms as compared to the transportation of individuals to a central location. One problem, of course, would be the responses and feelings of the individuals involved to the use of audiovisual devices as a substitute for face-to-face discussions. This certainly is an area where savings in transportation energy consumption could be achieved. NASA Ames has several people who have addressed this subject for a period of time and are continuing their activity. Thus, no problem statement in this subject area has been developed.

4.1.9 A Systems Analysis of the Energy Costs Related to the Design, Manufacture and Use of Aircraft

In order for reliable decisions to be made regarding any use of energy in the United States it is important that the total energy costs of that energy use be understood. For example, the energy costs associated with automotive transportation include, among others, the energy required to (1) build the automobile, (2) get automotive industry personnel to and from work, (3) make the steel and other construction materials, (4) fabricate metal, and (5) construct roads, as well as the actual gasoline used to operate the car. Similar energy expenditures are required to design, manufacture and use aircraft. The amount and character of all of these energy requirements must be determined in order to define the steps

which can be taken to conserve energy and to make a reasonable comparison of one transportation mode with another. To satisfy the need for this determination, a problem statement according to the title given above has been prepared.

4.1.10 Determine the Societal Impact of a Decrease in the U.S. Energy Growth Rate

Conservation of energy use was a principal recommendation from the Monterey workshop and many specific elements of this recommendation were included in their results. Some of the workshop participants were concerned that from an energy standpoint they had to recommend conservation as one requirement to assure future portable energy supplies, but on the other hand they had no information regarding the societal impact of a decrease in the U.S. energy growth rate. A problem statement of a proposed project in this vital area will be written by the University of Texas and included in their final report.

In the general field of conservation two problem statements have been prepared one of which is given in Section 5: "A Systems Analysis of the Energy Costs Related to the Design, Manufacture and Use of Aircraft."

The University of Texas has prepared a problem statement to "Determine the Societal Impact of a Decrease in the U.S. Energy Growth Rate."

Two actions by NASA/Ames Research Center are recommended:

- 1) Explore the possibility of a program to teach the economics of automobile operation to students through NASA's Work Enhancement Program.
- 2) Continue to contribute to the study and increased understanding of the opportunities for energy conservation through the substitution of communication for transportation.

4.2 EXPLOIT KNOWN OR INFERRED RESOURCES

4.2.1 Improve Secondary and Tertiary Recovery Methods for Petroleum

Only a small percentage (of the order of 10 to 30% of oil in the ground is recovered by present primary methods. It has been estimated

that within the continental United States there could be as much as 300 billion barrels of oil left in the ground after primary recovery. There is a good possibility that significant quantities of this residual oil can be recovered by what are called secondary and tertiary recovery methods. These include such techniques as water flooding of the oil bearing strata, the use of steam injection or hot gases, or forcing chemical solutions into the petroleum bearing rock to displace the oil. One of the recommendations of the workshop was to be certain that this source of additional petroleum would be made available. An investigation of this subject area revealed that the Bureau of Mines already has an active program in cooperation with industry under way (001183). The petroleum industry also is active on their own. The problem is extremely difficult in that different approaches are required for different oil bearing structures. The investigation of this subject area did not reveal any additional requirements needing attention, and, therefore, no program requirements for problem statement development were identified.

4.2.2 Develop Advanced Fracturing Techniques for Natural Gas Recovery

This is a subject area closely related to the one above and has as its purpose the liberation of additional natural gas from gas bearing structures. This also is an area with an active Bureau of Mines program as well as industry participation. As above, no program requirements for problem statement development were identified.

4.2.3 Conduct R&D on the Safe Handling of Nuclear Waste

One of the products of the present generation of nuclear reactors for electric power production is radioactive waste. This waste has a half-life of many hundreds of years, and its handling and storage is a problem of prime concern for long-term safety reasons. Obviously, the Atomic Energy Commission is conducting R&D in this area, and the Systems Studies Division of NASA Ames has a program on new and creative ideas in this subject area. Therefore, it was concluded that no program requirements for problem statement development could be identified.

4.2.4 Develop Techniques for Precisely Defining a Geothermal Resource

The Monterey workshop pointed out that geothermal energy was a clean energy source and that it would be to the benefit of the United States

to exploit these resources. In examining this subject area it was determined that there is a need to know if a geothermal location can furnish energy for a long period of time, such as 25 years. This kind of information is required as a basis for development of the resource and to determine if investment for any energy conversion equipment is appropriate. It, of course, would not be prudent to construct a large electric power generation plant at a geothermal location if the resource could not feed the power plant for several decades.

An investigation of this subject area reveals that this problem has been widely recognized and is high on the list of early requirements for the exploitation of geothermal energy (00039E, 00114E, 00246E, 00319E, 00675E and 00190E). More particularly, government agencies involved in geothermal work, namely, the Atomic Energy Commission, National Science Foundation and the Department of Interior, have programs and studies under way to find solutions to this problem. Since these agencies have active programs, no problem statements under this subject area were prepared.

4.2.5 Define Energy Load Requirements in Each of the Geographical Areas Where a Known Geothermal Resource is Located

The location of geothermal resources in the United States is quite well-known (see references listed in Section 4.2.4). The extent of these resources needs additional definition as described above. The amount and types of energy load requirements in areas around geothermal resources has not been defined according to this investigation. The purpose of this subject area is to determine the energy substitution opportunities related to known geothermal resources. In other words, this would be a means of defining the possible demand for energy that the geothermal resources of the United States could satisfy. A problem statement has been written on this subject area.

4.2.6 Waste Heat Utilization

The heat lost in industrial processes is a source of energy that could contribute to the country's energy balance if it could be recaptured economically. With the recent increase in costs for all forms of energy, industry, of course, is giving increasing attention to energy utilization, and conservation throughout industry is proceeding. Industry can improve their

thermal efficiency either through heat exchange between hot substances and cool substances or by process changes. Heat exchange technology is well advanced and relatively efficient. Process changes probably offer the biggest opportunity for energy conservation; however, they do have the biggest impact on capital investment and product quality. For these reasons it was felt that any work statement development in the field of process changes would not be appropriate.

In many industrial operations there is another heat source that might be recaptured. This is waste heat of low quality (for example, gas streams at 200° to 300°F) that ordinarily is discharged to the surrounding environment. Despite the low quality of the heat for further industrial use, it does contain a large number of Btu's for possible recapture. Two approaches to this problem have been identified, namely, the use of thermal electric devices and the use of mechanical, physical and chemical methods for recapturing this heat and essentially storing it. Problem statements in these two areas have been prepared.

4.2.7 Evaluate Hydraulic/Solvent Methods for Safely Increasing the Mining of Coal

Most projections of future energy requirements in the United States include an increased use of coal either directly or as a raw material to prepare clean burning gases, liquids and solids. Strong recommendations for the further use of this vital resource were made at the Monterey workshop. Better methods for the safe mining of coal certainly would be a contribution to greater use of coal. One approach that could have promise for improved coal production has been identified and a problem statement prepared. This covers the approach of underground mining of coal using hydraulic methods.

Under the general heading of exploiting known or inferred resources to assure supplies of portable energy, four problem statements have been prepared and are presented in Section 5.

- 1) Define energy load requirements in each of the geographical areas where a known geothermal resource is located.
- 2) Thermoelectrics for commercial power/process plant energy augmentation.

- 3) Evaluate mechanical, physical and chemical methods of energy storage.
- 4) Evaluate hydraulic/solvent methods for safely increasing the mining of coal.

4.3 DEVELOP NEW ENERGY SOURCES

Recommendations from the Monterey workshop relating to the development of new energy sources focused on four areas. These were solar energy, synthetic fuels from coal, oil shale development and the use of solid wastes.

4.3.1 Solar Energy

The sun as an energy source for terrestrial applications has received attention and been investigated for a number of years. Solar energy utilization falls into four categories which roughly relate to the temperature required for the operation. One category is the use of solar energy for water and space heating and cooling. Others are the concentration of solar energy for use in higher temperature industrial processing, cooking applications and solar energy as a thermal source for power generation.

An examination of all four of these categories was made for the purpose of identifying projects which would contribute to the more rapid development of solar energy applications (00039E, 00081E, 00666E, 00675E, 00043E, 00814E, 00341E, 00664E, 00670E and 00190E).

In the use of solar energy systems for water and space heating and cooling, a number of configurations have been field tested, and the capital and operating costs have been defined. The real requirement for expanding solar use in this application is to "generate an industry." Programs at the National Science Foundation recognize this requirement, and their future activity is designed to generate a solar energy industry for housing applications. No additional program requirements were identified.

In examining the possibilities and requirements for solar energy in the other three applications listed above, it was concluded that the application of this energy form for cooking was a minor one and, further, that simple devices for this application were available. When examining the requirements for the use of solar energy in high temperature industrial processing or in lower temperature power generation, the real requirement

appeared to be a need for a solar energy concentration system that was simpler in configuration and less expensive to build and assemble. It is in this area that a problem statement has been developed.

The photovoltaic conversion of solar energy to electrical energy was examined for future requirements. NASA has been active in solar cell development for spacecraft applications. Their requirements are for high reliability, which has been achieved, but the cost of such cells for terrestrial applications is too high. The solar cells commonly used generally are based on silicon. One area where an attempt has been made to decrease costs is to make silicon solar cells in sheet form. A program sponsored by NASA is under way in this area. It was determined that the present process for the manufacturing of silicon, the basic raw material, and its conversion into solar cells requires large amounts of energy. There are some who suggest that within the expected life of solar cells they never would be net energy producers. No project opportunities for problem statement development were identified in the solar cell area.

4.3.2 Synthetic Fuels from Coal

Coal is the most plentiful energy source available in the United States. Compared to petroleum or natural gas, it has several disadvantages including being a solid, which is more difficult to handle than a liquid or a gas, frequently having a sulfur content which is environmentally unacceptable, and its recovery involves hazards to personnel and the environment. Various technical programs since World War II have established processes for converting coal to gaseous and liquid fuels. These fuels include a low Btu gas, a medium Btu gas, a synthetic natural gas, a synthetic crude oil and a refined coal or char. Process development in all of these areas is planned as part of the Project Independence activity, and it was concluded that these programs would give the economic and technical information required to evaluate these processes. Three requirements that could speed up the introduction of synthetic fuels from coal were identified in our examination, and problem statements have been written as described below.

All synthetic fuels from coal processes require the addition of hydrogen to convert the coal from a solid to a liquid or gas. Generally, the

source of hydrogen is water or steam. New ideas for the manufacture of hydrogen of high purity would contribute to synthetic fuel development from coal. A problem statement in this area has been written.

A second requirement calls for the testing of aircraft fuels made from coal processing in aircraft engines. Although the general characteristics of liquid fuels from coal conversion are the same as natural petroleum, it is known that small changes in fuel composition can impact the reliability of aircraft engine operation. For example, several recent experiences in airline operation have shown that even slight changes in refinery operation can impact aircraft engine reliability. A problem statement covering this engine testing has been written.

The development of liquid fuels from coal, particularly aviation gasoline and jet fuel, would contribute to ample supplies of portable energy in the 1980's and 1990's. As discussed elsewhere in this report, such light liquid fuels would be similar to present petroleum derived fractions but they would have to be treated as separate new products for some considerable period of time. The introduction of any new technical product is a time consuming and difficult process which requires the building of confidence through the cycle of manufacturing, marketing and using. Present channels of commerce cannot be counted on to assume this task of new product introduction. Therefore, there is a need to define the requirements for "generating an industry" which would manufacture, market and use synthetic liquid fuels. Means to satisfy this need have been developed into a problem statement.

Catalysts commonly are used to assist in the conversion of solid coal to liquid synthetic crude oil. It is possible to directly convert coal to light liquid fractions such as aviation gasoline and jet fuel. Technology to perform this function was used by Germany in World War II, and such a plant has been operated in South Africa for over a decade. Neither of these experiences meets today's economic requirements, and this approach is frequently rejected for this fact. A reexamination of this approach and possible opportunities is indicated. New knowledge about catalysts and the commercial availability of many new catalytic materials could change this picture, and therefore, a problem statement has been prepared in this area.

4.3.3 Oil Shale Development

In the Western United States, generally on public lands, there is a large quantity of shale which contains 15 to 25 gallons per ton of a petroleum-like substance. Three technologies are available for separating the oily constituent from the shale, namely, in situ retorting, underground mining and aboveground retorting, and finally, strip-mining with aboveground retorting. There is considerable activity by the Bureau of Mines, the Atomic Energy Commission and various industrial companies in commercializing processes to make this fuel resource available. No needed requirements for project development were identified except that any aviation fuels developed from oil shale should be tested in aircraft engines as described above.

Tar sands are another source of liquid fuel; however, in the United States this type of resource is limited. The Bureau of Mines does have an activity related to fuel resource development from tar sands, and no additional requirements were identified.

4.3.4 Use of Solid Waste

Several years ago the Bureau of Mines conducted a study to determine the amounts of dry, ash-free organic solid wastes produced in the United States in 1971. This study estimated that the total waste generated amounted to 880 million tons in that year. Almost one-half of this amount was agricultural crops and food waste with manure and urban refuse being second and third in quantity (00099E). This study further estimated that only 136 million tons of various wastes were readily collectible. Even this smaller quantity had a net potential of replacing 170 million barrels of oil or 1.4 trillion cubic feet of methane.

Processes for using the waste directly in boilers for power generation have been proposed, tested and some of the problems identified. In this approach the heat content of the solid waste directly replaces oil, gas or coal for boiler firing. Other processes have been proposed for converting the waste to methane and/or a synthetic crude oil (00039E, 00663E and 00817E). Some of these processes have advanced to pilot and demonstration plant stages. An interagency panel under the leadership of the National Science Foundation has assessed the economic and technical

feasibility of power generation using solid waste. Their general conclusion is that the technology is satisfactory, but the economics still are uncertain and will require more experience.

An examination of this field indicated the need for a project which would advance the use of solid wastes for energy production as recommended by the Monterey workshop. The investigations on solid waste utilization have been directed to large quantity applications. An evaluation of process and equipment requirements for waste utilization in smaller quantities, as might be developed at feed lots, logging operations and rural areas, is indicated and such a problem statement has been written.

Problem statements under the general heading of "Develop New Energy Sources" have been prepared and are given in Section 5. Their titles are:

- 1) Design study for a solar energy concentrator.
- 2) Develop new approaches to a better hydrogen supply for synthetic liquid fuel development.
- 3) Test synthetic fuels to assure reliable operation in aircraft engines.
- 4) Develop an approach to "generating an industry" to manufacture, market and use new synthetic liquid fuels.
- 5) Direct conversion of coal to light aviation fuel.
- 6) Develop approaches and identify application areas for the small-scale conversion of wastes to power or synthetic fuels.

4.4 MISCELLANEOUS

The Monterey workshop made three recommendations which were studied under this miscellaneous category. The workshop expressed concern regarding the effect of fuel crises on the people of the United States and recommended that strategies be developed for dampening these effects. Such strategies might include action plans for rapid fuel cutbacks, the development of a petroleum stockpile and programs of fuel substitution. Within the Federal Government the responsibility for developing such strategies falls principally upon the Federal Energy Administration.

Within the scope of this program an examination was made to try to identify projects that would contribute to the soundness of any strategy development. No such project of a reasonable nature was identified.

One of the gaps in our knowledge about the value of energy is information about the tradeoff between energy use and time consumed. For example, the 55 mph speed limit for automobiles saves both fuel and lives but increases travel time. Air travel saves considerable time, at least for longer trips, but is fairly energy intensive. A further examination of the question of energy time tradeoff studies yielded the conclusion that such work would be of value and interest but would not have a significant impact on decisions relating to portable energy futures.

If the United States undertakes a program of the type presently described as Project Independence, there will be a need for increased numbers of skilled technical and operating personnel. The training of such personnel will be an important contribution to the success of any such national program. As discussed at the Monterey workshop, there certainly is a need to develop a plan for the education and training of personnel needed in the Project Independence program and by the industries that might result from such a program. It was decided, however, that the development of such a plan should await the definition of size, scope and direction of any national effort in the synthetic fuels.

The results of this activity of translating Monterey recommendations into relevant problem statements have yielded 18 subject areas in which problem statements have been prepared. These statements are presented in Section 5.

5. PORTABLE ENERGY PROBLEM STATEMENTS

5. PORTABLE ENERGY PROBLEM STATEMENTS

Eighteen problem statements have been prepared as a result of the processes and criteria described above. The philosophy used to select candidate problems is described in Section 3. The actual process of translating the workshop results, conclusions and recommendations (Section 2.3) into problem statements is described in Section 4.

Each of the problem statements consists of five parts. The introduction includes background, logic, need and justification. This is followed by a section on the project Objective, and then an Approach is given. The final two parts are the Task Description and an Estimate of Time and Costs. The programs described in these work statements are recommended for consideration by NASA in their research, development, technology and production plans in the portable energy field. They will assist NASA in identifying courses of action and strategies which will assist in assuring adequate supplies of acceptable forms of portable energy in the 1980's and 1990's.

The problem statement titles are given here, and the actual statements follow:

- 1) Systems Analysis of Energy Costs Related to the Design, Manufacture and Use of Aircraft
- 2) Evaluate Hydraulic/Solvent Methods for Safely Increasing the Mining of Coal
- 3) Relationship Between Energy Load Demand and Geothermal Resource Areas
- 4) Test Synthetic Fuels to Assure Reliable Operation in Aircraft Engines
- 5) Develop New Approaches to a Better Hydrogen Supply for Synthetic Liquid Fuel Development
- 6) Design Study for a Solar Energy Concentrator
- 7) Develop an Approach to "Generating an Industry" to Manufacture, Market and Use New Synthetic Liquid Fuels
- 8) Direct Conversion of Coal to Light Aviation Fuel
- 9) Develop Approaches and Identify Application Areas for Small-Scale Conversion of Wastes to Power or Synthetic Fuels

- 10) Thermoelectrics for Commercial Power/Process Plant Energy Augmentation
- 11) Automation Systems for Drilling Rigs
- 12) Application of NASA Sensor and Teleoperator Technology to Improved Mining and Mineral Resource Technology
- 13) Evaluate Mechanical, Physical and Chemical Methods of Energy Storage
- 14) Study to Determine Availability of the Most Probable Aviation Fuels
- 15) An Analysis of Institutional and Associational Barriers to the Implementation of New Portable Fuel Sources
- 16) Specification for the Production of Alternative Scenarios by Simulation
- 17) Social-Demographic Influences on the Demand for Air Transportation
- 18) Delineation of Potential Societal Dislocations Resulting from Efforts to Establish Energy Independence in the United States.

5.1 SYSTEMS ANALYSIS OF ENERGY COSTS RELATED TO THE DESIGN, MANUFACTURE AND USE OF AIRCRAFT

5.1.1 Introduction

One of the most valuable insights gained from the painful experience of the 1973-1974 Oil Embargo is the depth of our ignorance of the important role that energy plays in our individual and national lives. After decades of cheap, seemingly endless availability, energy had become a "given" in countless industrial and governmental decisions. By giving primary consideration to monetary efficiency, energy costs were ignored and mankind's natural heritage squandered.

It is now abundantly clear that such profligate behavior can no longer be countenanced. The conservation of energy and other natural resources must assume its rightful position as an integral, even pivotal, factor in decisions which impact the manufacture and use of goods and services.

The design and implementation of effective future conservation practices requires a detailed understanding of the current energy costs of goods and services. The task of acquiring that understanding is extremely

complex and perhaps best suited to the tools of systems analysis. The magnitude of the task is such that it will be necessary to address limited sectors of the economy rather than the economy as a whole, concentrating initially on those sectors which are apparently the most energy intensive. The design, manufacture and use of aircraft is a prime example of such a sector.

5.1.2 Objective

The objective is to determine the energy costs associated with the design, manufacture, certification and use of aircraft, with the eventual objective of identifying opportunities for the conservation of energy and other natural resources.

5.1.3 Approach

A systems analysis of the energy costs related to the design, manufacture, certification and use of aircraft should be performed. The analysis should not be limited to the energy directly consumed by the aircraft and airline industries, but rather should also consider the energy consumed by those portions of other sectors of the economy which are necessary for their functioning (e.g., metal mining and refining, textiles, employment related travel, etc.). The program that should be performed will define the sectors of the economy which have an appreciable impact on the energy costs of aircraft and will establish the methodology for determining those costs. The next step will involve the detailed systems analysis and identification of areas of potential resource conservation.

5.1.4 Task Description

The contractor shall perform a systems analysis of the energy costs related to the design, manufacture, certification and use of aircraft according to the tasks outlined.

- Task 1: Perform a search of the technical and industrial literature to establish a data base that will permit the selection of those areas of the economy which contribute significantly to the energy costs of the design, manufacture, certification and use of aircraft. Sufficient data should be obtained to allow rough order of magnitude calculations of energy costs. The areas which are deemed to be of significance will be chosen by mutual agreement of the contractor and NASA project engineer.

- Task 2: Establish methodology for detailed analysis of the energy costs.
- Task 3: On the basis of the results of Tasks 1 and 2, perform the detailed systems analysis and identify potential areas for resource conservation.

5.1.5 Estimate of Time and Costs

10-12 months, \$200 to 300K.

5.2 EVALUATE HYDRAULIC/SOLVENT METHODS FOR SAFELY INCREASING THE MINING OF COAL

5.2.1 Introduction

The underground mining of coal is the most hazardous of all work activities in the United States. Of the dangers to the miner, roof falls and explosions form the major elements relating to fatalities. Roof falls generally occur very close to the working face during the fracturing process. The fracturing of the coal by mechanical means also produces much coal dust and liberates methane in the very area where the bits on the mining machines provide a source for igniting this potent combination. The liberated coal dust is also a health hazard when inhaled, causing the infamous "Black Lung" disease of the coal miner.

Liquids under pressure are capable of fracturing the coal into the requisite sizes and eliminating the ignition source, the coal dust, and much of the hazard of roof falls by the ease of remotely controlling such systems. Transport of the fractured coal pieces in the liquid medium also is a possible option. For coal fracturing a steady high-pressure liquid stream can be used, or pulsed liquid jets will fracture coal and not require as much liquid.

The first consideration for hydraulically fracturing coal underground would be to use water since it is inexpensive. However, the United States presently is actively investigating the liquefaction of coal for the purpose of producing a synthetic crude from which transportation fuels such as jet fuel and aviation gas can be refined. The mediums proposed for dispersing the coal to permit liquefaction by the addition of hydrogen are hydrocarbon in nature. The use of such liquids in a hydraulic mining system should be considered.

The concept of the use of a liquid fracturing system for underground coal mining is not new. Some actual operations are said to exist in the Soviet Union and some technical papers have been published and patents issued in the United States. Much of the non-Russian activity seems to have been limited to concept reduction to practice supported by limited testing. With the acknowledged importance of coal as a national resource and with the emphasis being placed on coal as a raw material for the production of synthetic crudes, a source of portable energy, an examination of this mining method is appropriate.

5.2.2 Objective

The prime objective of this proposed program is to determine if this alternative underground mining technique is a real and potentially valuable alternative to presently used mechanical methods. If its probable value can be established within reasonable limits, then a program plan for field testing and demonstration on a sufficient scale to show its commercial applicability will be developed.

5.2.3 Approach

An examination of the Russian and United States technical and patent literature should be made and from these data some candidate underground hydraulic mining systems would be defined. Estimates of capital and operating costs would be performed for the candidate system(s) along with supporting engineering calculations. Identification of possible technical or operational problems also should be made. From these activities a plan would be derived to cover required testing of specific segments of candidate system(s), operation of a pilot scale complete system, and finally a field demonstration unit for developing interest in commercialization of underground hydraulic coal mining.

5.2.4 Task Description

The contractor will undertake the following specific tasks. The first three tasks are considered to be part of a Phase I activity for initial funding. The final task is part of a Phase II program which would proceed only if the results of Phase I showed promise of achieving a safe and economical underground hydraulic coal mining method.

- Task 1: Examine the technical and patent literature, including such literature from the USSR, and develop a data base of technical, engineering, economic, operational and environmental information in this field.
- Task 2: Using the information developed in Task 1 and/or the engineering skill of the contractors personnel, define one or more systems for possible underground hydraulic coal mining. Such definition shall include general layout drawings, engineering calculations, operating procedures and estimates of capital and operating costs. Comparisons with present coal mining methods also should be made.
- Task 3: From the results of Task 2 develop a plan to cover the required testing of specific segments of the candidate system(s), the construction and operation of a pilot scale system, and a field demonstration unit to develop interest in commercial exploitation.
- Task 4: Undertake the plan as defined in Task 3.

5.2.5 Estimates of Time and Costs

Phase I (Tasks 1-3), 12 months, \$200 to 300K.

Phase II (Task 4). Depends on Phase I results but would require 3 to 7 years and greater than \$10 million for a complete Phase II activity.

5.3 RELATIONSHIP BETWEEN ENERGY LOAD DEMAND AND GEOTHERMAL RESOURCE AREAS

5.3.1 Introduction

The rapid development of uses of the geothermal resources of the United States was one of the strong recommendations of NASA's Portable Energy Workshop. Post-workshop examination of the recommendation has identified two major problems to implementing the utilization of this resource. First, there is a problem in defining the extent and quantity of some geothermal resources. This information is necessary for planning capital investments for facilities to utilize the resource. This problem is receiving strong attention from several government agencies and industry. Second, there is a need to know the energy load demand for all types of energy in the general area of a geothermal resource. Representatives of a number of utility companies have stated that they need to know the energy load demand around a geothermal resource in order to plan any capital investments.

Potential geothermal sources generally are located in areas of rather recent volcanic activity. These areas may or may not be strategically located in relation to the electric power grid or power generation plants. Even though a geothermal resource may not be at the right location or in an area of high demand, its value could be significant. A 10 megawatt geothermal power station at Mammoth, California, should be very attractive economically, but the same station near Los Angeles would not be.

5.3.2 Objective

The objective is to assist in the acceleration of geothermal development by identifying the geothermal resources of the highest potential as defined by the total energy demand in the general area of the resource. This information could then be used by public utilities to develop plans for geothermal resource utilization. Another objective of the project is to define and begin to create a demand for use of geothermal resources.

5.3.3 Approach

Identification of many geothermal resources in the United States has been accomplished, and these known locations would be used in this study. From this list of known geothermal energy sources a reasonable number would be selected for more detailed examination. The locations selected should include a variety of situations regarding location, nearby population, industry in the area, competitive energy sources, etc. The present total energy load demand in the area of the geothermal activity then would be developed. It is important that a total demand be determined including electricity as well as steam, hot water and space heating. The location of the resource in relation to the electric power grid in the area is an important consideration. Although it is commonplace to consider converting geothermal energy to electricity, the heat content of the geothermal source may better be used directly or indirectly as a source of steam, hot water or hot air.

5.3.4 Task Description

The contractor will undertake the following tasks:

- From lists of known geothermal resources in the United States select a representative number for study in this

project. The number selected (possibly 15 to 50) should reflect a variety of probable energy load demands in the adjacent area.

- Develop detailed information on the total energy load demand in the general area of the geothermal resource. This load demand should include types of energy used (e.g., coal, natural gas, etc.) and the applications of the energy forms (e.g., space heating, water heating, industrial processing, electrical power generation, etc.).
- Prepare a final report including preliminary recommendations on suggested uses of the geothermal resource.

5.3.5 Estimate of Time and Costs

Nine to 18 months and \$250 to 500K, depending upon the number of geothermal sites selected.

5.4 TEST SYNTHETIC FUELS TO ASSURE RELIABLE OPERATION IN AIRCRAFT ENGINES

5.4.1 Introduction

A number of the technical programs of the newly established Energy Research and Development Agency probably will be directed to obtaining liquid fuels from solid energy forms. Particular attention is expected to be paid to processes producing a shale oil from shale deposits in the western U. S. and to manufacturing synthetic crude oil from coal. It is known that shale oil and synthetic crude oil will be hydrocarbon in nature and, in a general sense, can be described as similar to natural occurring petroleum crude. The refining of shale oil and synthetic crudes to produce typical petroleum-based products such as gasoline, aviation gas, and jet fuel has received some attention. It is expected that well-known refining methods will be used to process the synthetic liquid products.

The specific characterization of fuels for aviation from nonpetroleum sources will be required as these programs proceed and, most particularly, assurance that such fuels can offer reliable operation in aircraft engines must be established. The determination of the physical and chemical properties of such synthetic aviation fuels is not sufficient to establish this assurance. There have been reported and documented examples of unreliable aircraft operation due to changes in refining methods of petroleum products. Thus, testing of the fuels in actual aircraft engines, including the associated fuel storing and handling system, will be required.

5.4.2 Objective

The objective is to assure that new synthetic fuels for aviation use will perform reliably in both the engine and the fuel handling system. Operation reliability for both piston and jet engines is to be established.

5.4.3 Approach

The new synthetic fuels for aviation would be tested in selected standard piston and jet engines, including the fuel storage and handling system normally associated with the respective engines. The engine test beds should have the capability of taking and recording measurements normally made in good engine testing practice, and the engine operating cycles should correspond as well as possible to normal operating cycles of the engine in actual use.

5.4.4 Task Description

The contractor will test new synthetic aviation fuels in piston and jet engines, as appropriate, including the fuel storage and handling system normally associated with each engine. It is anticipated that the engines will be installed in a fully instrumented test bed capable of taking standard measurements required to assure reliable engine operation and, further, capable of operating the engines on a cycle which reasonably corresponds to the normal use cycle of the engine when installed in an airplane.

The selection of the number and type of synthetic aviation fuels will depend on the progress achieved in the numerous government and industry supported programs directed toward fuel development. It is expected that the many approaches and process variations that will be studied will yield a large number of candidate fuels, e.g., 50 to 500.

5.4.5 Estimate of Time and Costs

This fuel testing activity will require a multimillion dollar facility and an operating budget of several million dollars per year. Active testing of candidate synthetic aviation fuels would be expected to continue for a period of at least 5 to 10 years.

5.5 DEVELOP NEW APPROACHES TO A BETTER HYDROGEN SUPPLY FOR SYNTHETIC LIQUID FUEL DEVELOPMENT

5.5.1 Introduction

The physical state of hydrocarbon type energy sources is directly related to the hydrogen-carbon ratio. The highest hydrogen-carbon ratio is present in methane and natural occurring gaseous compositions. Liquid petroleum crudes have a lower ratio, but not as low as coal and lignite which have the lowest hydrogen-carbon ratio of all natural occurring hydrocarbon energy sources. Thus, the basic problem of creating gaseous and liquid hydrocarbons from coal is one of adding hydrogen to the coal under the influence of temperature and pressure. The cost and quality of this hydrogen raw material will have a significant impact on the availability and price of new synthetic liquid fuels for aviation applications.

Presently, the most common method of supplying hydrogen for manufacturing synthetic fuels from coal is to react steam and air or oxygen with a portion of the coal to produce a gaseous mixture of carbon monoxide and hydrogen. If oxygen is used, then no diluent nitrogen is present in the gases. Further catalytic reaction of this mixture with additional steam converts the carbon monoxide to carbon dioxide and additional hydrogen. The carbon dioxide can then be removed. Certainly this approach does use readily available and inexpensive raw materials; however there are a number of problems that add to the costs. First, high temperature separation of the hydrogen from the mixture is indicated, but inexpensive and reliable techniques for this separation are not presently available. Cooling of the gases before separation is an alternative, but this is relatively expensive, and then the hydrogen has to be reheated for use in the synthesis. The use of coal as the raw material introduces impurities such as sulfur dioxide which often impairs later processing. Thus new approaches for a better hydrogen supply for synthetic fuel development are needed.

5.5.2 Objective

The objective is to analyze alternate methods for manufacturing gaseous hydrogen to be used in the preparation of new liquid synthetic fuels. From the analysis select one or more approaches for further laboratory and bench scale examination. The approaches selected should be based on sound physical and chemical data and sufficiently accurate

economic estimates to suggest a reasonable opportunity for success in the experimental phases.

5.5.3 Approach

Methods of hydrogen preparation to be analyzed should include, among others, reactions for chemically extracting hydrogen from aqueous systems, reactions for chemically extracting oxygen from aqueous systems leaving gaseous hydrogen, methods for thermally decomposing water and simultaneously removing the hydrogen, and various schemes based on electrolysis. Each candidate preparation considered should be supported by appropriate physical-chemical data such as heats of formation, free energies, boiling and melting points, etc. If this analysis looks promising, a general process flow sheet would be prepared along with a preliminary economic estimate.

This physical, chemical, economic and engineering analysis should identify processes with a reasonable probability of success and within each process would focus on the high leverage points of technical and economic uncertainty where the initial technical and experimental efforts should be directed. Comparisons with the present technology of reacting coal with oxygen and steam should be made throughout the analysis.

5.5.4 Task Description

The contractor will perform the following specific tasks to develop new approaches to a better hydrogen supply for synthetic liquid fuel development:

- Task 1: Develop a list of candidate procedures for hydrogen preparation. The list should include creative new approaches and concepts from the technical and patent literature.
- Task 2: Using the techniques of thermodynamics, kinetics, chemical engineering and economics, analyze each candidate process for its probability of success. Identify specific portions of each process where there are uncertainties to be overcome or where experimental efforts would have the highest leverage in advancing the process development.
- Task 3: Based on the analysis performed in Task 2, select one or more candidate reactions and plan initial experimental programs to remove uncertainties and to conduct proof-of-principle experiments.

- Task 4: Conduct the initial experimental programs to further define and select the better approaches to hydrogen supply.

5.5.5 Estimate of Time and Costs

Tasks 1-3. Six months, \$50 to 75K.

Task 4. This task will depend on the results of Tasks 1-3, but it probably will require 9-18 months and \$100 to 300K.

Note: Good success through Task 4 would then call for programs successively involving process development units, pilot plant and demonstration plant activities.

5.6 DESIGN STUDY FOR A SOLAR ENERGY CONCENTRATOR

5.6.1 Introduction

Interest in the use of solar energy might be said to go back at least to 212 BC, when Archimedes is said to have destroyed the Roman fleet in Syracuse harbor by using solar energy reflected by a mirror or mirrors. In more recent times, the use of parabolic reflectors for the concentration of solar energy for cooking by troops of Napoleon III in Africa was suggested in 1860. Since the 1940's, particularly, various uses of solar energy have received active attention.

The terrestrial applications studied fall primarily into four major categories:

- 1) Low temperature applications for building space air conditioning and for water heating, generally not involving concentration of the solar energy.
- 2) Small devices for cooking, using simple and inexpensive concentration techniques and producing temperatures in the neighborhood of 150° to 200°C.
- 3) High temperature solar furnaces, providing temperatures as high as 4000°K, used primarily for research in high temperature physics and chemistry and the properties of refractory materials.
- 4) Installations for the production of power, such as electrical power for distribution, or in specialized applications such as the distillation of sea water.

Of these applications, the first three have received by far the most attention. It is the purpose of this program to consider the opto-mechanical problems associated with the practical and economical concentration of solar energy for use in the fourth application, power production.

The parabolic reflector represents a straightforward approach to the optical problem, and in one form or another, it has been the basis of most of the devices requiring very efficient concentration of solar energy as in solar furnaces intended to obtain as high temperatures as possible. By 1957, there were 26 such furnaces in the United States and at least six in foreign countries, with Japan and Australia both quite active in this area. From a theoretical viewpoint it can be shown that parabolic mirrors are in fact not optimum for solar energy concentration (e.g., Baum and Strong, in *Solar Energy*, July 1958). This is true because the performance of a paraboloid degrades rapidly for off-axis rays, and the 0.5-degree angular width of the sun is enough to make this effect noticeable. However, the practical problems associated with the fabrication and operation of medium-sized or larger systems make the optically elegant solution suggested by Baum and Strong unattractive, and, indeed, exact paraboloids of large size are prohibitively expensive.

Even before the problems of fabricating large paraboloids are considered, it is necessary to examine the requirement to direct the solar energy to a target from a large range of solar elevation and azimuth angles. The theoretically best approach is to use an auxiliary heliostat to direct the sun's rays as nearly as possible along the optical axis of the paraboloid regardless of the sun angle, since, as has been noted above, the paraboloid cannot tolerate even modest off-axis angles. Moreover, with this technique the relatively inexpensive flat mirror of the heliostat can be made large enough to fill the paraboloid completely even for large angles between the sun and the optical axis. Examples of this approach are common in solar furnace designs; for example, an Australian design uses a heliostat on the ground and a paraboloid on a tower, while the large solar furnace in the eastern Pyrenees feeds its paraboloid with a multisection heliostat built on a mountain slope.

A considerably simpler method, where less efficient solar energy concentration can be tolerated, is to use a long cylindrical parabolic mirror with a tube target containing water or some other working fluid along its axis. If now the tube is somewhat larger than the theoretical line image of the sun, the system will work fairly well over a period of hours without adjustment. Fairly large excursions of the sun in the center plane of the system tend merely to shift the line image along the tube, with acceptable defocusing across its width. Proper pointing of the configuration can make most of the diurnal travel of the sun occur in this plane. Thus, auxiliary mirrors are eliminated, and solar tracking requirements much reduced, at the expense, for many applications, of acceptable reductions of efficiency.

The problems with the fabrication, installation, and operation of large paraboloids, especially the circular ones, are very difficult. Consideration must be given not only to the achievement of the required figure, but also to its stability in the presence of mechanical and thermal stresses, and to the capability of the installation to withstand wind loadings and other weather phenomena. The French approach in the Pyrenees is to approximate the figure with a very large number of individual segments. Indeed, this concept can be carried to the point of building up the collecting mirror area from many plane mirrors, all arranged to point at the desired target. This has been the technique used in a major Russian project.

Both the French and Russian projects alluded to above are worth considering in a little more detail. The French first built a 60 Kw pilot furnace near Montlouis, in the eastern Pyrenees. This was followed by a 1 megawatt furnace capable of producing 4000°K temperatures, at nearby Odeillo. The concentration system of the large furnace includes a large paraboloid 45 m wide and 40 m high (the bottom of the paraboloid is truncated a bit). This paraboloid is built up of 9500 initially flat back-silvered glass plates, curved under mechanical constraints to conform very nearly to the desired figure. The paraboloid is fed by 63 heliostats, each containing 180 flat back-silvered glass plates of total area 45 m^2 . The 63 heliostats are mounted in an array on a hillside, and individually rotated in altitude and azimuth by a hydraulic system, in such a way that they can fully illuminate the paraboloid over a wide range of sun angles. The

furnace has been used for melting refractory materials, studying the chemical deposition of molybdenum and tungsten borides, and other investigations of a similar nature.

The Russian project is a steam generating plant; it is the largest of the relatively few projects for this use of solar energy. It has been described by Aparisi, Baum, and Garf in a pamphlet entitled "High Power Solar Installations" abstracted in Solar Energy, April 1961. A system has been developed in a helio laboratory for a solar station which, it is claimed, can attain a capacity of 10^7 kilocalories per hour and more (i. e., in excess of 10 megawatts). It is designed to produce steam at a pressure of 30 to 35 atmospheres. The collecting mirrors have a total area of $19,395 \text{ m}^2$, made up of 1293 flat reflectors directing the energy onto a steam boiler. Each 3 m x 5 m reflector consists of 28 flat mirrors. The reflectors are mounted on 23 separate trains on a number of circular tracks. Azimuth tracking is accomplished by moving the trains on the tracks, while zenith pointing is achieved by rotation of each reflector about a horizontal axis with electric motors.

5.6.2 Objective

This is a design study for the opto-mechanical configuration for concentration of solar energy for use in the production of power at a suitable location on the ground. The solar energy concentrator should be capable of directing about 3.5 megawatts of solar power on a suitable target at noon and at 40 degrees north latitude. Solar tracking should be possible for solar elevation angles from 5 to 64 degrees and azimuth angles from due east to due west.

The objective of this program is to provide data on the technical and economic feasibility of developing a power production facility of about 1 megawatt output capacity using solar energy as the input source. This is to be accomplished by selecting a design approach and carrying the preliminary design far enough to determine the technical problems involved and to justify the cost estimates made. The details of the equipment for converting the solar energy into mechanical energy, and thereafter into electrical or chemical energy, are not part of this program. However, the target may be taken as a modification of a conventional boiler, producing steam at about 300°C for the working fluid in a conventional heat engine such as a steam turbine.

5.6.3 Approach

Available Solar Energy Density. The solar constant is $2 \text{ Cal cm}^{-2} \text{ min}^{-1}$ on a surface normal to the sun at the top of the atmosphere, or 1395 watt m^{-2} . For a clear atmosphere and fairly high sun angles, a reasonable average value for atmospheric transmission is about 0.8. The mirror reflectivity should be about 0.9, and near midday the cosine of the angle of incidence of the sun's rays on the mirror will be in excess of 0.9. Therefore, about 0.65 of the energy measured by the solar constant is reflected to the target, or about 900 watt m^{-2} of mirror area. This is the basis for establishing the area of collecting mirrors needed for a specified power level. In particular, if an output mechanical power of 10^6 watts is required and a thermodynamic efficiency of 0.3 is assumed for the heat engine (a conservative value for a Rankine cycle engine operating at 300°C), 3700 m^2 of collecting mirrors are needed.

Target Size. The angular size of the sun is 0.5 degree; therefore the minimum image size with a perfect imaging system is $0.087f$, where f is the system focal length. A flat mirror does not change the divergence of the rays striking it, so at any distance d a plane mirror of width W will illuminate an area $W + 0.0087d$ wide. However, since a plane mirror has no aberrations, a large number of mirrors can be directed at a single area, over a wide range of angles, with dimensions about the same as that for a single mirror. For practical mirror segment sizes and reasonable working distances, satisfactory concentration of the sun's energy can be achieved for most purposes other than those demanding the highest attainable temperatures. To a good approximation, the target size is given by $W + 0.0087d$ for a large number of mirrors all of width W .

Baseline Concept. In view of the foregoing, a baseline or "straw man" design concept has been developed. It consists of a number of relatively small heliostats all directed at a target which, other than the source of heat energy, is essentially a conventional steam boiler. The system can be thought of as derived from the Odeillo furnace, but eliminating the paraboloid, or from the Russian power plant, but eliminating its system of concentric circular tracks. This straw man concept represents a feasible, it is believed, reasonable approach, but the analysis has not been carried far enough to assure that it is a near-optimum system. It

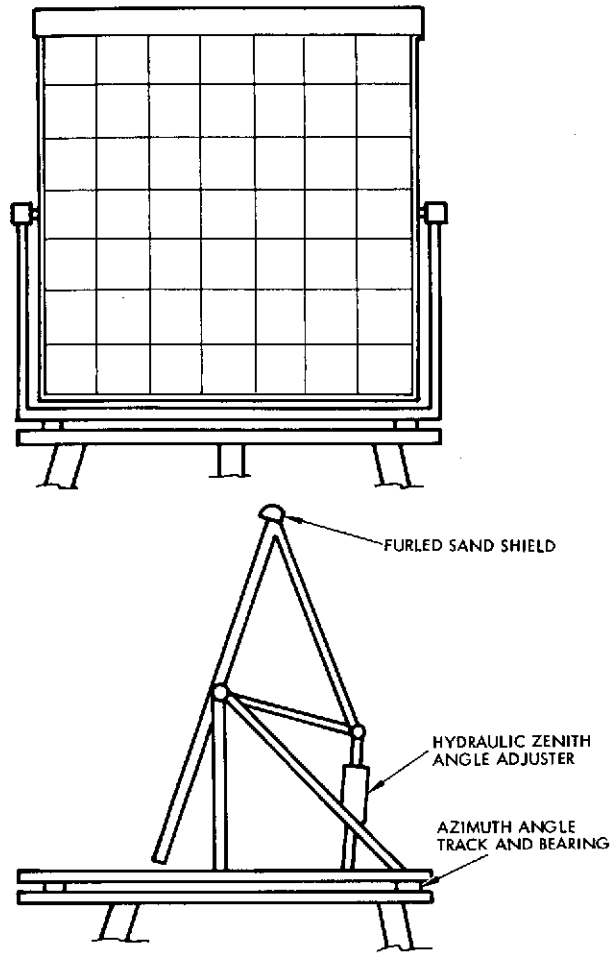
should be considered only as an initial starting point, with deviations in detail or in basic concept encouraged if they lead to a more effective system.

The collecting system consists of 81 7 m x 7 m mirrors for a total area of 3969 m². Each mirror is made up of 49 1 m² facets. The angles of the facets are adjusted in the vertical cross section to provide pseudo-focusing in this direction, but their normals all point in the same horizontal direction. The mirror assembly concept is illustrated in Figure 1. Pointing of the assembly in a vertical direction, i. e., about a horizontal axis, is possible over a range from 2.5 to 42.5 degrees, so that they can point the sun's rays to the target for sun elevation angles from 5 degrees above the horizon to 85 degrees above the horizon, which permits their use in all suitable regions of the United States. This vertical motion is achieved with a hydraulic actuator.

Azimuth pointing is accomplished by rotation of the assembly on a circular track on the base. While only about ± 50 degrees rotation is required for sun tracking, a full ± 90 degrees motion is possible, so that in case of high winds the assembly can be oriented edgewise to the wind. A furlable mirror shade can be drawn over the mirror surface, in much the way an old-fashioned window-shade operates, to protect it from blowing sand or other severe weather.

The mirror segments are made of back-silvered plate glass. This is relatively inexpensive and the reflectivity can be maintained until the surface becomes badly scratched or pitted. The shades are provided to reduce the rate at which this will occur. Other materials, such as Alzak, might also be considered as alternatives.

The mirrors are arranged in the configuration shown in Figure 2. They are located 9 m apart in both the N-S and E-W directions, or on 12.73 m centers along the 45 degree rows. This somewhat open spacing is necessary to prevent obstruction between mirrors at low sun angles in the morning and evening. The 27 mirrors nearest the target are on approximately the same level as the target; the next 27 are raised about 8 m higher in order to reflect unobstructed sunlight to the target; and the last 27 mirrors are raised about 16 m, to clear those ahead of them. The complete set is contained in a 243 m x 243 m area, somewhat offset from



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Figure 1. Mirror Concept

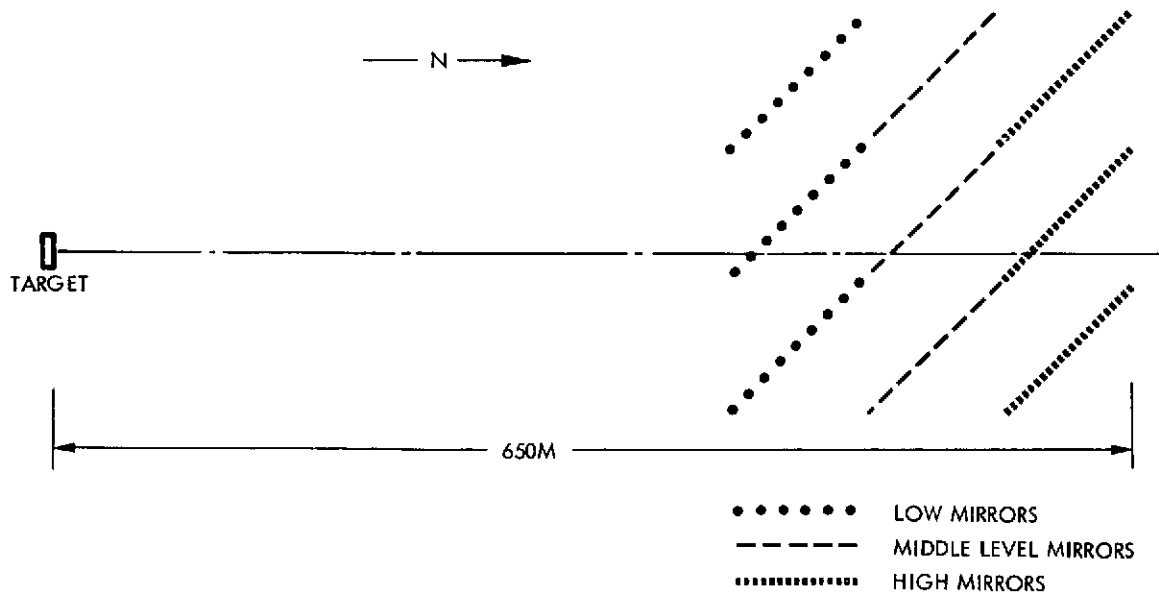


Figure 2. Mirror Layout

symmetrical location relative to the N-S line to the target, to make the angles from the mirrors at the ends of the center diagonal row to the target equal in magnitude.

The distance of the farthest mirror assembly to the target is 655 m. Therefore, the spread of the beam due to the angular size of the sun is 5.72 m. The effective vertical width is 1 meter, so the target must be 6.72 m high, nominally. However, the range of sun elevation angles produces some defocusing at the extremes, analogous to spherical aberration, which amounts to about 0.8 m. If this is allowed for, and a pointing error of ± 0.2 degree is permitted, the required target height is increased to 12.1 m.

In the horizontal direction, the effective mirror width is 7 m giving a nominal target width of 12.72 m. This must be increased by 0.17 m for the maximum obliquity effect and 5.38 m, as in the vertical, for a pointing error allowance, to give an actual target width of 18.3 m.

During the usable period of the day, the individual mirror assemblies must be rotated about their horizontal and vertical axes independently of one another. Moreover, their required motions will change slightly from day to day. However, the required motions can easily be preprogrammed and stored on tape. The control of the mirror motions can then be achieved by a control system similar in principle and of no greater complexity than that used in an automated lathe.

Cost Estimate. Each mirror assembly includes a support structure, a drive structure and mechanism, and a mirror assembly, which includes the mirror segments, a frame, a supporting and protecting back, and a sand protection shade mechanism. In addition, a foundation must be provided for each. The raised mirrors must also be mounted on short towers, or the equivalent. A nominal value has been given for these, but they could be entirely eliminated if the mirror field area sloped upward to the north at about a 5-degree slope. This might represent one of the criteria for site location, or it might be cost effective to grade an otherwise acceptable site to achieve this. System costs include the control system, and the costs of surveying and grading. Again, a nominal cost for grading has been estimated; it could be increased to achieve net overall savings by reducing tower requirements. Target, i.e., boiler costs have not

been included, nor those of turbines and generators, since they are not a subject of this study, and will be substantially the same as for a conventional power plant.

The following table gives a summary of the estimated costs:

<u>Cost Element</u>	<u>Unit Cost</u>	<u>Number Required</u>	<u>Subtotals</u>
Support structure	4.2K	81	340.2
Drive structure	1.0	81	81.0
Mirror assembly	3.9	81	315.9
Foundation	1.5	81	121.5
Short tower	2.5	27	67.5
Tall tower	5.0	27	135.0
Control system	200.0	1	200.0
Survey and grade	60.0	1	60.0
Total			1321.1K

This cost estimate includes both material and fabrication costs, but not design. It is based entirely on a per-unit cost ignoring, on the one hand, savings that would arise from the fabrication of multiple elements and, on the other, general supervision, which would increase the cost. The final estimated figure of \$1321 per kw is, of course, higher than the installed costs of large coal or nuclear power plants but certainly very attractive for a small installation which does not require further expenditures for fuel.

5.6.4 Task Description

This is a design study for the opto-mechanical configuration required for the concentration of solar energy for power production. The study shall provide a conceptual design in sufficient depth to permit analysis of the feasibility and cost of the configuration. The system requirements are as follows:

- The potential output mechanical power of the facility using the Concentrator shall be approximately 10^6 watts at peak (noon operation).

- Nominal conditions shall be:
 - 1) Latitude of site, 35°N
 - 2) Assumed heat engine thermal efficiency 0.3.
 - 3) Working fluid, water (steam) at 300°C .
- The system shall be capable of operating with sun elevation angles from 5 to 74.5 degrees, and at all azimuths at which the sun is 5 degrees or more above the horizon.

The contractor shall perform the following tasks:

- Task 1: Survey the results of prior investigations, including, but not limited to, the solar furnace at Odeillo, France, the Russian 10^7 kilocalorie/hour solar steam plant design, and the Chile project for water distillation and electrical power production using solar energy.
- Task 2: Consider feasible methods and perform sufficient tradeoff analyses to establish a preferred approach.
- Task 3: Develop a conceptual design for the opto-mechanical configuration of the concentration system and the target characteristics to meet the system requirements. The boiler design is not a part of the study, but the size and optical absorption characteristics of the target must be consistent with established practice in boilers of this size. The design shall include provisions for tracking the sun over the required ranges, specifying the means for obtaining the appropriate pointing angles and for controlling them. The configuration shall be capable of withstanding weather extremes to be found in the Southwestern U. S., nonoperating if appropriate. This shall include winds up to 60 mph, and blowing sands.
- Task 4: Provide parametric data on design implications for variations from the nominal conditions to include size, cost, and other pertinent factors. Estimates shall be included of the maximum and minimum parameter values for which the design approach is practical.
- Task 5: Document the results of Tasks 1 through 4 in a final technical report, and present a briefing covering the study results.

5.6.5 Estimates of Time and Costs

The study should cover about 6 months through submission of a draft final report, with 1 month for NASA review, and 1 month for the required revisions, a total contract period of 8 months.

It is estimated that a meaningful study at the depth required should cost about \$100 to \$200K.

5.7 DEVELOP AN APPROACH TO "GENERATING AN INDUSTRY" TO MANUFACTURE, MARKET AND USE NEW SYNTHETIC LIQUID FUELS

5.7.1 Introduction

The development of new industries associated with new products traditionally has occurred for strong and obvious reasons. Frequently, a new industry has developed as a result of a need expressed by the social structure. For example, the airline industry satisfied a general social and business need for rapid transportation to permit more frequent person-to-person contacts. Thus an industry producing and using reliable and economical airplanes developed. Other strong reasons for new industry development have been the loss of raw materials (e.g., kerosine for whale oil), new more economical technology resulting in a less expensive and superior product (e.g., synthetic versus natural fibers), wars and blockades (e.g., development of synthetic dye industry in the U. S. during and after World War I), and government laws and regulations (e.g., the air pollution control industry).

The United States is embarking on a national activity to increase its internal supply of all forms of energy. Elements of this activity include Project Independence, the formation of the Federal Energy Administration and the Energy Research and Development Agency, Congressional appropriations for energy programs, significant industry activities in the broad field of energy, and high public interest in energy affairs. One aspect of all this effort is unique in that traditionally strong and obvious reasons for the development of new industries may not, and probably will not, be present for the next 25 to 50 years. Nevertheless it appears to be in the national interest to "generate an industry" in some new energy sources and forms. NASA, with an aeronautical charter and responsibility, is interested in the requirements to manufacture, market and use new synthetic liquid fuels as needed by the aviation industry.

5.7.2 Objective

The objective is to explore various available alternatives and to develop an approach to "generating an industry" which will manufacture, market and use new synthetic liquid fuels. The approach could use all or part of the present industries associated with liquid fuels, but need not be limited in that regard.

5.7.3 Approach

Two synthetic liquid fuels, namely aviation gas and jet fuel, will be selected for detailed study although it would be recognized that these two may not be able to stand alone as an industry. The exploration of various available alternatives would consider a number of elements in defining the alternatives and finally selecting an approach to industry generation.

These elements should include:

- Raw materials for liquid fuel manufacture
- Manufacturing process(es) used (technical description – capital and operating costs)
- Product specifications and quality
- Probable manufacturing location(s)
- Transportation methods and costs of raw materials and products
- Government regulations
- Product costs and pricing structure
- Requirements for user acceptance
- Product distribution channels
- Technical support and service requirements
- Competitive liquid fuels

Information associated with the elements listed above would be used to define various alternatives for generating a synthetic liquid fuels industry.

The defined alternatives would be analyzed for economic, operational, market, social, legal and governmental acceptance and viability as a means of selecting an approach to generating a synthetic liquid fuels industry.

Throughout such a program the points and degree of uncertainty should be identified as well as the actions required to remove the uncertainties.

5.7.4 Task Description

Furnishing the necessary personnel, materials and services, the contractor(s) will perform the following specific tasks and activities:

- Task 1: Develop the information necessary and appropriate to the best possible description of the elements listed under "Approach" above. Additional elements should be described as indicated by this effort.
- Task 2: Using the information developed in Task 1, define alternative approaches to generating a new synthetic liquid fuels industry. These definitions should include a full description of the industry according to each alternative approach.
- Task 3: Analyze the alternative approaches defined in Task 2 for economic, operational, market, social, legal and governmental acceptance and viability and use the results of the analysis to select a preferred approach. List and describe the steps, actions and milestones that would be required to generate the new synthetic liquid fuels industry according to the approach selected.
- Task 4: Begin the implementation steps necessary to generate a new synthetic liquid fuels industry as described in the approach selected.

5.7.5 Estimate of Time and Costs

Tasks 1-3: 10-12 months, \$150K

Task 4: Depends upon approach selected.

5.8 DIRECT CONVERSION OF COAL TO LIGHT AVIATION FUEL

5.8.1 Introduction

In an era of increasing uncertainty of supply and costs for petroleum products, the search for less vulnerable energy sources has become an important national goal. Since coal represents our country's most abundant fossil fuel resource, much of the research and development effort now under way is aimed at its conversion to more convenient gaseous and liquid fuels.

The major emphasis in the work being done to convert coal to liquid fuels has been on producing heavy synthetic crudes. These processes are relatively simple in concept and basic chemistry. They do, however, present many difficult engineering problems associated with the high temperatures and pressures required for the reactions. Another disadvantage to the production of synthetic crudes is that it is an intermediate product which must be further treated in more or less conventional refineries to obtain fuels compatible with current combustion equipment.

A number of other processes have been developed or tested in the past which are designed, usually with the aid of a catalyst, to convert the products of coal gasification directly to light liquid fractions suitable for use as aviation gasoline or jet fuel. The Fisher-Tropsch Process, which involves the catalytic conversion of synthesis gas (mainly CO and H₂) into light fractions, is perhaps the best known of those processes. This and other such processes were developed during a period when they were not economically competitive with cheap oil and were largely ignored. It now seems appropriate that these processes be reexamined in the light of the current world energy climate to determine if they offer any potential economic and/or energy conservation advantages over processes that produce synthetic crude.

5.8.2 Objective

The objective is to assess the economic and energy conservation advantages and disadvantages of processes for the direct conversion of coal to light aviation fuel.

5.8.3 Approach

A thorough reexamination of processes which have been developed or proposed for the direct conversion of coal to light aviation fuel should be performed. All of the technical and economic aspects of the processes should be analyzed in the context of the current and probable future costs of petroleum and other competing energy technologies. The net energy output from the processes should be as important a consideration as their economic efficiency. On the basis of the assessment, recommendations for future research and development programs should be made.

5.8.4 Task Description

The contractor shall perform an evaluation of the economic and energy conservation advantages and disadvantages of processes for the direct conversion of coal to light aviation fuel according to the following tasks:

- Task 1: Perform a thorough search of the technical and patent literature to establish a data base that will permit an evaluation of current and proposed processes for the direct conversion of coal to light aviation fuel.
- Task 2: On the basis of the data assembled in Task 1, evaluate the processes in terms of their economic, technical and energy efficiency advantages. The processes should be evaluated relative to each other and to other competing energy technologies.
- Task 3: On the basis of the evaluation performed in Task 2, recommendations will be made for future research and development in this field.

5.8.5 Estimate of Time and Costs

6-8 months, \$60 to 80K.

5.9 DEVELOP APPROACHES AND IDENTIFY APPLICATION AREAS FOR SMALL-SCALE CONVERSION OF WASTES TO POWER OR SYNTHETIC FUELS

5.9.1 Introduction

During the 1970's the United States has become increasingly dependent on petroleum-based fuels for the country's energy requirements. Practical limitations of domestic production and the extreme uncertainty and astronomical cost increase of foreign supplies make it imperative that methods be found to make the most efficient use of the available petroleum-based fuels. A particularly attractive means for stretching petroleum supplies is the complete or partial substitution of fuels derived from other, preferably renewable, sources.

More than 2 billion tons of organic wastes are generated in the United States each year. Most of that material, including municipal garbage, industrial wastes, scrap paper products and plant and animal wastes is being discarded. Although only a fraction of the total wastes is readily available and amenable to conversion to useful fuels, that quantity does represent a substantial, largely untapped, resource.

Some efforts are already under way to use some of the enormous quantities of waste materials. Several cities are now burning their wastes to product heat and power. Plants are also being built or are planned for the production of fuel from garbage by pyrolysis and from cattle manure by bioconversion.

A major block to the full utilization of wastes as a resource is the fact that it is available generally in relatively small quantities in any one location. Another difficulty derives from the fact that the waste materials are generally under the control of relatively small entities; municipal governments, agricultural cooperatives, cattle feedlots, etc. These organizations are often ill-equipped financially and technically to assess properly the complex questions associated with the determining feasibility of using their wastes and the best method for its conversion. Therefore, a clear need exists for the development of flexible approaches to the utilization of the wastes and a consistent set of criteria that will aid small political and economic entities in determining the best method of dealing with their individual situations.

5.9.2 Objective

The objective is to develop approaches and identify application areas for small-scale conversion of wastes to power or synthetic fuels.

5.9.3 Approach

In order to meet the objective of this program, a thorough understanding must be gained of the quantities, locations and compositions of the principal types of organic wastes and of the processes that have been used or porposed to convert them to power or synthetic fuels. The information collected must then be employed to formulate criteria that will aid prospective users of waste in small-scale applications. The criteria should assist in matching the size, location and composition of a waste resource with the most effective method of converting it to power or synthetic fuels.

5.9.4 Task Description

The contractor shall develop approaches and identify application areas for small-scale conversion of wastes to power or synthetic fuels according to the tasks outlined below.

- Task 1: A literature and patent study shall be conducted to assemble information concerning the quantity, location and composition of the principal types of organic wastes and the processes that have been used or proposed for the conversion of such wastes to power or synthetic fuels.
- Task 2: On the basis of the data gathered in Task 1, a series of criteria shall be formulated which will aid in the selection of the most efficient approach or process for the conversion of wastes in an individual situation. The criteria shall consider the characteristics of the economic or governmental unit which generates and/or uses the wastes, as well as the characteristics of the waste itself.

5.9.5 Estimate of Time and Costs

12 months, \$100 to 120K.

5.10 THERMOELECTRICS FOR COMMERCIAL POWER/PROCESS PLANT ENERGY AUGMENTATION

5.10.1 Introduction

The thermoelectric module makes use of the Peltier and Seebeck effects to transform heat into electricity. The basic concept of thermoelectricity has been in use since the early 1800's. The fabrication of devices producing usable levels of power at reasonable efficiency became practicable with the availability of semiconductor materials and the development of solid state physics theory in the early 1950's. Since that period, extensive development by the U. S. Atomic Energy Commission has resulted in the use of thermoelectric converters for a variety of applications in space, underwater, and in cardiac pacemakers where long life and high reliability under unattended operating conditions are mandatory.

The advantage of thermoelectrics is that electrical power can be produced without employing moving components, which leads to an extremely reliable device. In addition, the thermoelectric couples can be sealed from harmful effluents, allowing operation in most environments. The disadvantage of thermoelectrics is that they are a relatively low efficiency device. Maximum overall system efficiencies obtainable, at high operating temperatures, is approximately 10%. An achievable efficiency

at a hot junction temperature of 300° to 400°F is about 5%. However, even at this modest efficiency, it is estimated that approximately 75 megawatts of additional power could be obtained from thermoelectrics alone operating off the stack gas (300° to 400°F) of a large commercial power plant [1000 MW(e)].

The initial cost of thermoelectric materials is rather high, but considering reliability and the fact that minimal maintenance is required, the long-term cost could be competitive with existing power systems. The estimated cost of the unit is \$500/kilowatt (e) based upon a reasonable production level. This estimate was made by a well-known commercial thermoelectric couple manufacturer based on a PbTe/BiSbTe thermoelectric couple.

5.10.2 Objective

The purpose of this project is to analyze, design, and test a Thermoelectric Energy Augmenting System (TEAS) which uses a thermoelectric converter in the stack of a commercial power/process plant. The converter will use the exhaust gas or a portion of it as a source of heat to maintain a temperature drop across the thermoelectric elements and produce supplemental electrical power.

The major objective of the TEAS is to demonstrate the feasibility of using thermoelectrics to augment the power producing capabilities of commercial power/process plants. Overall thermoelectric efficiency values on the order of 4 to 7% will be demonstrated. Long-term performance (in the order of 10 to 20 years) and stability under varying load conditions, with little or no maintenance, are also achievable.

5.10.3 Approach

The TEAS will use state-of-the-art thermoelectric materials which are well characterized both thermally and electrically. Minimal development of the thermoelectric couples will be required; however, considerable work will be done to optimize the system from a structural, thermal and electrical performance standpoint. Several TEAS configurations will be considered, including a ring-type design which is built into the stack wall and a baffled plate design which is supported in the stack and is exposed to direct gas flow. In addition, the use of water heat pipes will

be investigated to improve heat transfer efficiency and, in turn, maximize the TEAS performance.

A system capable of operating at a thermoelectric hot junction temperature up to 400°F with the ability to withstand thermal cycling, such as might be encountered in the stack of a commercial power/process plant, will be demonstrated. Economically, the TEAS will demonstrate a long-term national energy savings with no additional environmental shortcomings (air pollution).

5.10.4 Task Description

The contractor team, including a selected thermoelectrics material subcontractor, will undertake the following tasks. In addition, agreements will be made with one or more industrial power/process plants for pilot system installation and testing. By performing the tasks listed below, the feasibility of a Thermoelectric Energy Augmenting System (TEAS) for industrial applications will be demonstrated.

Task I - Plant Evaluation and Selection

The performance and configuration of several commercial power/process plants will be evaluated to determine which are the most attractive for the incorporation of a TEAS. The parameters to be evaluated will include, but will not be limited to:

- Plant location
- Stack temperature distributions (radial and horizontal)
- Stack effluents
- Plant configuration
- Ease of TEAS installation

An evaluation criteria system will be used to rate the various plants and will result in a plant selection based solely on engineering/economic considerations.

Task 2 - Analytical Design of a Pilot Scale TEAS (approximately 10 kw)

Analytical design techniques will be used to predict the performance of, and optimize the configuration of, the TEAS. The following design parameters will be analyzed in detail:

- Thermoelectric materials
- Operating hot junction temperature
- Methods of heat rejection and thermal control
- TEAS configuration and dimensions
- Optimal location of TEAS within stack
- Structural tradeoffs
- Effects of effluents on performance
- System reliability

Task 3 — Design Verification Testing

Perform component level tests to characterize the performance of the thermoelectric couples to be used in the TEAS. Long-term life tests and short-term performance tests will be conducted on the pilot scale configuration to determine the following:

- Long-term TEAS performance characteristics
- Thermoelectric property characterization including:
 - 1) Seebeck coefficient
 - 2) Electrical resistivity
 - 3) Thermal conductivity
 - 4) Open circuit voltage
 - 5) Internal resistance
- Effect of stack effluents on performance
- Structural integrity of couples

The design verification tests will be performed to verify analytical predictions and assure attainment of full system goals prior to the TEAS fabrication phase.

Task 4 — Hardware Fabrication and Predelivery Testing of a 1 Mw Unit for Field Testing

After design verification tests have indicated that achievement of the design goals is possible on the large-scale system, fabrication of a 1 Mw unit will be initiated. Couple fabrication will be performed by the thermoelectric subcontractor, and the couples will be assembled into modular packages which can be assembled to form the TEAS. The modular

approach will allow great flexibility in TEAS configurations in addition to increasing system reliability. Each individual thermoelectric module will be tested prior to being packaged into the final TEAS converter.

Modular testing will include:

- Power output
- Load voltage
- Load current
- Electrical continuity

After assembly into the TEAS converter, installation into the structural subsystem will be performed. The entire TEAS assembly will then be subjected to predelivery tests to assure proper operation during field testing.

Task 5 – Demonstration Field Tests

Following fabrication and predelivery testing, field tests will be conducted on the TEAS installed in a stack of an operating commercial power/process plant from installation and start-up through performance characterization and long-term testing. Parameters to be measured will include:

- Power output during start-up
- Performance at various loads (I-V curve generation)
- Performance as a function of stack temperature and stack effluents
- Heat rejection/control subsystem performance
- Long-term TEAS performance stability and reliability

Periodic data will be obtained to determine possible modes of degradation; these will include:

- TEAS open circuit voltage
- TEAS internal resistance
- Overall TEAS thermal conductance

Task 6 - Design Manual

Based on the work performed and the results obtained in Tasks 1-5, a design manual will be prepared that can be used for reliable engineering and design of commercial units of 1 Mw capacity and larger.

5.10.5 Estimate of Time and Costs

<u>Task</u>	<u>Duration (months)</u>	<u>Manpower Costs (\$K)</u>	<u>Hardware Costs (\$K)</u>	<u>Totals (\$K)</u>
1	3	15		15
2	6	90		90
3	6	90	15	105
4	4	100	1,500	1,600
5	6	100		100
6	3	30		<u>30</u>
				1,940

Note: Tasks 1-3 could be completed for approximately \$205K before committing to the large field test installation.

5.11 AUTOMATION SYSTEMS FOR DRILLING RIGS

5.11.1 Introduction

A number of the prime sources of energy, i. e., oil, natural gas, geothermal and geopressure, require the use of drilling rigs. Some in situ concepts for recovering energy from oil shale and coal would use a rig to reach the deposit and initiate reaction. At the present time, there are approximately 1500 onshore rigs operating in the U. S. with an additional 150 operating offshore.

NASA's Portable Energy Workshop made a strong recommendation to exploit our known resources, and one requirement to fulfill this recommendation is to increase the number of drilling rigs. In verbal communications with knowledgeable university and industry people, estimates were given that the U. S. will need 4000 to 6000 drilling rigs in the 1980 to 2000 time frame in order to meet the nation's energy requirements.

Two approaches may be initiated to develop this well drilling capability: (1) greatly expand existing rig manufacturing capability and (2) increase the efficiency of new and existing rig forces. In all probability a combination of 1 and 2 will be needed to meet the requirements.

However, increasing the efficiency of the drilling rig force has several advantages:

- Greatly reduced capital investment
- Decreased demand for raw materials and energy
- Early and rapid impact in increasing the number of effective operational rig days
- Decrease in demand for experienced labor which is in short supply
- Could use NASA-developed sensor and control technology.

The major disadvantage is that, in general, the drilling rig labor force is not well schooled in automation and some difficulty could arise in instituting automated operation.

A systematic evaluation of drilling operations and the potential for automation has not been studied in any detail. Estimates of increased efficiency potential range from 30 to 40%, but these figures have not been verified. Drilling contractors have insufficient funds and no capability to pursue development in rig automation, and the energy producing companies are not working in this area. Thus, the government should sponsor some initial investigations.

The savings potential for automating drilling rigs appears to be attractive. With 1500 onshore rigs operational in the U.S. a 20% increase in drilling efficiency would result in an effective increase of 300 rigs. If each rig averages four 10,000-foot holes per year, the effect of rig automation could be 1200 additional onshore resource wells or 12,000,000 hole-feet per year. Resultant capital savings from the effective increase of 300 onshore rigs would be about \$450 million assuming an average rig cost of \$1.5 million each. If a similar 20% effective increase were obtainable with offshore units, an effective increase of 30 rigs would be achieved. At an average cost of \$25 million each this would approximate a savings of \$750 million. The added cost of automating should be significantly less than the above potential savings. Future savings based on new rig production would be additional.

5.11.2 Objective

The objectives are to (1) perform a systems study of drilling operations and define those elements of the system that may be amendable to automation and (2) determine those instruments and sensors that may aid in increasing the drilling efficiencies of existing and new drilling rigs.

5.11.3 Approach

A sequence of tasks will be required to analyze, identify and describe drilling operations and procedures which are susceptible to control with state-of-the-art instruments and sensors, the use of which will improve the operating speed or efficiency of the rig. Tradeoff studies and optimization can then be used to evaluate the concepts being considered. Attractive alternatives will be incorporated into an implementation plan.

5.11.4 Task Description

The contractor will perform the following tasks:

- System Assessment. Evaluate and define the systematic procedures and methods used in normal well drilling operations. This activity should include:
 - 1) Discussions with drilling contractors as to methods and techniques used
 - 2) Discussions with oil tool manufacturers as to sub-component automation potential
 - 3) Consultations with rig builders as to possible automation opportunities.
- System Requirements. Candidate automation elements will be identified and prioritized as to impact on total operational efficiency, normal operating procedures and system configuration. Sensor and implementation requirements will be described.
- Tradeoff Study and Optimization. The concepts selected in Task 2 will be subjected to systems and cost effectiveness studies. Examination will be made of design and manufacturing requirements.
- Implementation Planning. A plan for both preliminary and field testing of the concepts and systems that appear attractive at the completion of Task 3 will be prepared. Cost and time estimates are to be included in the implementation plan.

- Final Report. Included in this report should be the general conclusions and recommendations of the project, descriptions of the concepts, ideas, systems and sub-systems considered, the logic and methodology used to select the best automation opportunities and the proposed implementation plan.

5.11.5 Estimate of Time and Cost

Nine to 15 months and \$350K.

5.12 APPLICATION OF NASA SENSOR AND TELEOPERATOR TECHNOLOGY TO IMPROVED MINING AND MINERAL RESOURCE TECHNOLOGY

5.12.1 Introduction

Two types of mining for the recovery of mineral resources are used commonly throughout the world. The predominant method is strip mining where the overburden covering the deposit is removed, and the mineral resource then is recovered by the use of large mechanical shovels, drag-lines, etc. The second technique, underground mining, leaves the overburden in place but sends men and machines down to the deposit through shafts and tunnels. Underground mining is a hazardous occupation with many health and safety problems, all of which lead to higher costs and lower production rates. With many mineral resources, however, deposits suitable for strip mining are fast being consumed so that less concentrated underground deposits must be exploited. One means of contributing to the safe and productive exploitation of underground mineral resources is to operate the underground mining machinery and related transport equipment remotely. This would not require the development of new technology, such as is required with in situ coal gasification, but it would require the joining of two known technologies.

5.12.2 Objective

The objective is to define the operations required to be performed and the sensor and teleoperator equipment necessary to remotely perform these designated underground mining operations. In this study the mining operations will be limited to disintegrating the mineral at the mining face and to move it back from the immediate mining area. Concepts for systems suitable to perform these mining operations remotely then should be described and defined.

5.12.3 Approach

This effort should be limited to one mineral resource, and it is suggested that coal be selected. A significant amount of operational and economic data on underground coal mining exists and could be used for baseline comparisons. Underground coal mining presents a broad combination of mining problems combined with health and safety requirements such as fire, explosion, dust and roof falls. A definition of the operations performed would be made, and this definition would include such physical data as distance of movement, weights, pressures, etc., as well as a description of the environment in which the sensors and robotic equipment will operate. Discussions of the man-machine relationships also would be included. Upon the completion of this definition, the sensors and remote operating equipment which could perform the operations would be determined. Possible configurations then could be selected and sketched and preliminary specifications and cost estimates prepared. Technical, operating and economic uncertainties would be identified at this point. If any of the concepts and configurations should sufficiently promise to be technically and economically attractive, an implementation plan for component and system testing and field use trials would be developed.

5.12.4 Task Description

The contractor(s) will perform the following tasks:

- Task 1: Define, from an engineering and operational standpoint, the operations performed in disintegrating the mineral at the deposit face and removing it back from the immediate area.
- Task 2: Describe sensors and teleoperator equipment that could be used to perform remotely the operations defined in Task 1.
- Task 3: Using the sensors and robotic equipment selected in Task 2, develop configurations that could remotely perform the desired operations and prepare preliminary specifications and cost estimates. Identify technical, economic and operating uncertainties.

- Task 4: Prepare an implementation plan that would remove the uncertainties, cover component and system testing and use trials under field conditions.

5.12.5 Estimate of Time and Costs

Tasks 1-3: 12 months, \$250 to 500K.

Task 4: This task would require several years and \$5 to 10 million.

5.13 EVALUATE MECHANICAL, PHYSICAL AND CHEMICAL METHODS OF ENERGY STORAGE

5.13.1 Introduction

Energy is often either available or needed at the wrong time, in the wrong place and in the wrong form or quality. The major demand for electricity occurs during the day and requires generating capacity that is not used during off-peak, evening hours. Conversely, solar energy is available during the day and, at least in the near term, its most promising application is for water heating and space conditioning of individual residences which is in greatest demand after sundown. "Waste heat" from furnaces and industrial processes is often of too poor quality (low temperature) for efficient use in conventional steam driven engines.

Many of the supply/demand mismatches of time, place, form and quality could be alleviated by appropriate methods of energy storage. The most widely used, nonvoltaic storage method at this time is pumped water storage. This option suffers from the disadvantages of relatively low efficiency and few appropriate water storage locations. Many other mechanical, physical and chemical methods of energy storage have been tested or proposed; super flywheels, hot water, compressed air, change in state (latent heat), exothermic/endothermic chemical reaction couples are just a few examples.

Most of the research performed in this field has been fragmentary and focused on a narrow area of application. Therefore, there is a real need for a coordinated examination of current energy storage technologies with an eye toward establishing criteria for evaluating their relative merit and using an evaluation based on those criteria to establish future research and development goals.

5.13.2 Objective

The objective is to evaluate current and proposed mechanical, physical and chemical methods of energy storage in order to establish future research and development goals.

5.13.3 Approach

A thorough survey of current energy storage technologies should be performed and criteria established for their evaluation. The criteria should establish a consistent framework for evaluation of the relative technical and economic attributes of the technologies. The evaluation should then be performed and used to help define goals for future energy storage research and development.

5.13.4 Task Description

The contractor shall perform an evaluation of current and proposed mechanical, physical and chemical methods of energy storage according to the tasks outlined below.

- Task 1: Perform a thorough search of the technical and patent literature to establish a data base which will permit an evaluation of current and proposed mechanical, physical and chemical methods of energy storage.
- Task 2: On the basis of the information assembled in Task 1, a set of consistent criteria should be established to evaluate the energy storage methods. The criteria should include consideration of economic and technical factors related to specific use applications.
- Task 3: Perform the evaluation of the energy storage methods and on that basis establish desirable goals for future research and development in the field.

5.13.5 Estimate of Time and Costs

6-8 months, \$60 to 80K.

5.14 STUDY TO DETERMINE AVAILABILITY OF THE MOST PROBABLE AVIATION FUELS

5.14.1 Introduction

The Systems Studies Division (SSD) under contracts NAS2-8444 and NAS2-8445 with the University of Texas and TRW Systems, Inc., has concluded Phase I of a study entitled, "Technology Assessment of

Portable Energy RDT&P¹¹. This study phase established a broad energy policy and data base, generated six future energy demand scenarios and 24 alternative fuel process options, sponsored an interdisciplinary workshop focused on defining specific portable energy issues, problems and near-term actions, and assessed explicit portable fuels conclusions and recommendations relevant to NASA aviation and intermodal transportation R&T.

The interdisciplinary technology assessment workshop participants reviewed the portable energy futures from the viewpoints of their diverse backgrounds and experience. As might be expected, the focus of the workshop was broad and, in effect, looked at the total energy future with some concentration on portable fuels energy as a subset. These participants identified more than 80 conclusions and recommendations, which were classified by the contractors and NASA into three broad areas relating to energy conservation, exploitation of known domestic energy resources, and development of new clean fuels. Subsequent assessment and evaluation by the NASA/Industry/University Teams resulted in reducing these workshop recommendations and conclusions to a manageable number of relevant portable energy problem statements. The implementation of even a few of these statements would require significant governmental action, including interagency discussions and the allocation of the important resources of capable people and funds. Immediate steps can be taken to combine some elements of certain of these statements into a program of value to NASA's aviation research and technology responsibilities. This near-term activity is entitled, "Study to Determine Availability of the Most Probable Aviation Fuels". This study will describe the most probable aviation fuels and their resource base in the 1980's and 1990's. The study output will provide guidance for structuring a compatible aviation propulsion R&T program.

Coal and shale are prime energy resources, but offer no direct possible use as aviation fuels. Many active or planned government and industry projects are designed to convert these domestic resources into other prime energy forms such as synthetic gas and crude oil. The primary rationale for this study rests on NASA's responsibility to undertake relevant aviation propulsion R&T which will provide the aviation and air

transportation industry with propulsion systems that are compatible with the most probable aviation fuels in the 1980's and 1990's. Although both coal and oil shale are our most plentiful domestic energy resources, there are many questions concerning their successful extraction and conversion into useful fuels that remain unresolved. These questions involve not only technical and economic considerations, but also important related issues such as environmental impact, labor supply and training, extraction and conversion safety, and the broad question of the respective roles of government and industry. The proposed study would attempt to assess the potential impact of these issues and to resolve the questions relating to future aviation fuels availability.

5.14.2 Objective

The principal objective of this study is to describe the most probable aviation fuels in the 1980's and 1990's, and to determine the feasibility of providing an adequate supply of hardware-compatible aviation fuels derived from domestic coal or shale at stable competitive prices within this time frame.

5.14.3 Approach

The SSD in conjunction with a joint industry/university team will undertake a six-month study to determine the availability of the most probable aviation fuels in the 1980's and 1990's.

The industry team will have primary organizational, technical and administrative responsibility for this synthetic aircraft fuels study. They will be explicitly responsible for: (1) Describing the present aeronautical fuels infrastructure and near-term trends; (2) identifying present and potential aircraft fuels processes and their resource base; (3) analyzing coal and shale-based synthetic aircraft fuels technical and economic options; and (4) determining the availability of the most probable aviation fuels in the 1980's and 1990's, together with (5) NASA aviation R&T implications.

The university team will assist the industry team in the previous five tasks, and will have primary responsibility to: (1) identify barriers, problems, and influences on present aircraft fuel supply, and (2) investigate barriers, problems, and influences affecting the implementation of each technical option analyzed by the industrial team.

Although both teams have explicit responsibilities, they will at all times coordinate their work tasks under direction of the industry team.

The NASA team, comprised of selected representatives of the SSD (ARC), LeRC, and NASA Headquarters, will be responsible for overall program management and funding. It will participate in the analysis of synthetic fuels technical and economic options, in the identification of implementation barriers, problems and influences, and in the determination of the availability of the most probable aviation fuels and their impact on aviation propulsion R&T. The SSD will appoint a principal Study Monitor who will coordinate the federal role in the conduct of the study.

5.14.4 Task Description

The industry/university team shall conduct a study to define, assess and describe the availability of the most probable aviation fuels in the 1980's and 1990's and their impact on NASA aviation propulsion R&T. The study tasks required to define these objectives are:

- Task 1: Describe the present aeronautical fuel infrastructure and near-term trends (~5 years). This task would describe, and thus initiate, an understanding of the present raw material, manufacturing, transportation, marketing and use patterns for aviation fuels. It would be the reference point for several subsequent tasks described below.
- Task 2: Identify barriers, problems and influences in present aircraft fuel supply. It is most likely that the introduction of a new synthetic aviation fuel would be more easily accomplished if the present commercial channels could be used as much as possible. Thus, an identification and understanding of the type and character of present channels is required.
- Task 3: Identify present and potential processes and resource base. Processes for the preparation of aviation fuels would be identified and described in general technical terms, and the resource base necessary to implement all of the processes would be defined. This base would include resource extraction, transportation system and distribution channels among others.
- Task 4: Analysis of coal and shale derived synthetic aircraft fuels technical options. This analysis would include commercial experience, technical uncertainties, development programs and time required, capital and operating costs, raw materials necessary, and projected use patterns.

- Task 5: Investigate barriers, problems and influences regarding the implementation of each technical option analyzed in Task 4. This investigation is similar to Task 2 above except that in this task the approach considers the questions in light of synthetic aviation fuel products.
- Task 6: Determine the availability of the most probable aviation fuels in the 1980's and 1990's. Using the results and information developed in Task 3, 4 and 5 above, an assessment and determination of the most probable aviation fuels option(s) would be prepared. Resources and time required to introduce the product(s) would be defined.
- Task 7: Identify the implication to NASA aviation propulsion research and technology. The introduction of any synthetic aviation fuels could have an impact on NASA's planned research and technology programs. This task will identify and describe these future impacts.

5.14.5 Estimate of Time and Costs

Six months, \$200K.

5.15 AN ANALYSIS OF INSTITUTIONAL AND ASSOCIATIONAL BARRIERS TO THE IMPLEMENTATION OF NEW PORTABLE FUEL SOURCES

5.15.1 Introduction

The U.S., as a modern industrial society, is characterized by a high degree of efficiency and, at the same time, vulnerability. The societal specialization that facilitates production and distribution activities involves numerous components corresponding to a complex division of labor. These components, functioning in tasks critical to a given activity, can also effectively deter that activity. Depending on the component, the deterrence can take such forms as failure to finance, failure to innovate in research and development, work-stoppage, refusal to use or consume, or failure to adapt relevant legal-regulatory standards. The transportation function gives a prime example of vulnerability precisely because it underlies all other functions and characteristics of a highly mobile, technologically advanced society.

At a juncture in societal development when implementation of new portable fuel sources is critical for the continued optimization of the transportation function, it is vital to analyze and understand the barriers to such changes. These barriers may be sought under two major headings.

First, institutional barriers arise when change confronts the complex of customary practices in a given area, such as in the political, economic, or educational institutions. Second, associational barriers form when proposed changes violate, or are defined as violating, the interests of particular groups, such as labor unions, corporations, or governmental agencies. Institutional barriers reflect the basic human force which compels individuals to resist alterations in the social structure. Associational barriers refer more specifically to processes of equilibrating the material, and to a lesser degree the psychological, interests of various and often competing groups.

5.15.2 Objective

The proposed study would identify institutional and associational barriers to specified changes in portable fuel sources, and, on that basis, would analyze possible means for overcoming such barriers.

5.15.3 Approach

Effective implementation of changes in specific energy situations involving new portable fuel sources can come about only by considering the barriers to those changes. Such a study will provide knowledge toward overcoming initial barriers in addition to developing insight regarding the consequences of specific changes. The study would involve the following procedures.

- 1) Development of a descriptive system model of critical components in the portable fuel area.
- 2) Application of that model to identify and describe barriers to changes in portable fuel sources.
- 3) Verification of the barriers tentatively described through extensive interviewing with individuals from labor, industry, government and the general population.
- 4) Assessment of requirements to overcome the verified barriers.
- 5) Development of forecasting procedures on the basis of the system model to identify possible (and probable) consequences of implementation of the stated changes for each of the population sectors interviewed.

5.15.4 Task Description

Following the general approach stated above, the contractor will undertake the following specific study tasks:

- Task 1: Identify and describe the major kinds of new portable fuel source situations.
- Task 2: Identify the institutional and associational components relevant to the portable fuel area, modifying as necessary to then describe specific new portable fuel situations.
- Task 3: Define the bases of opposition flowing from these components to the proposed changes.
- Task 4: Provide a system analysis of the interrelationships of components in the portable energy sector. This system analysis should be sufficiently complete to allow continued projections for additional new portable fuel source situations after the present project is finished.
- Task 5: Outline incentives and alternatives for implementing changes in portable fuel sources.
- Task 6: Discuss component-specific implications of the proposed changes.

5.15.5 Estimate of Time and Costs

6-12 months, \$20K.

5.16 SPECIFICATION FOR THE PRODUCTION OF ALTERNATIVE SCENARIOS BY SIMULATION

5.16.1 Introduction

The Production of Alternative Scenarios by Simulation (PASS) method, which utilizes a technique similar to war gaming, would be used to generate predictions of possible sequences of events resulting from the adoption of a given governmental policy with respect to energy. A simulation team consists of a number of individuals, each an expert in a particular area expected to have a significant influences on the course of events (e. g., labor, legislative affairs, the voting public, science, etc.) plus a team of coordinators, also representing a broad base of backgrounds. The individual experts might be geographically dispersed, while the coordinating team must be based at a single location.

A scenario simulation would be started by defining a set of initial conditions for the "society" (i.e., economic conditions, fuel supplies, employment, social stratification, etc.) and a set of constraints that will govern future decisions. The latter will be established by the particular policy being evaluated. A perturbation on the initial conditions (say a tax increase) will be introduced and each of the experts will respond by predicting the reaction of his particular interest group over a short time horizon (one or two years). These changes will be collected by the coordinating team and consolidated into a new set of initial conditions for the next time step. The process is continued until the ultimate time horizon for the scenario is reached, and the coordinating team documents the complete scenario.

The process described above may be carried out over a long period of time and without formal meetings of the participants. When the scenario is completed, however, the participants will meet in a workshop session to review the scenario and to consider what alternative courses of action they might have pursued given the hindsight provided by the exercise.

5.16.2 Objective

To test the workability of the simulation approach for energy-related scenario generation.

5.16.3 Approach

- 1) The specific energy situation to be simulated will be identified and defined.
- 2) Two independent simulation teams will be selected with members who represent industry, government, and other groups involved in the situation as defined in 1.
- 3) These teams will work simultaneously on the generation of a limited number (one or two) of scenario productions.
- 4) The scenarios from the two teams will be coordinated by the directing team, and differences discussed at a forum involving the two simulation groups.

5.16.4 Task Description

- Task 1: Coordinating team writes initial conditions, constraints and proposed perturbations.

- Task 2: Simulations teams are defined by identification of the groups which would have decisional influences on the energy situation studied.
- Task 3: Members of simulation teams are recruited. A meeting of all participants is held to formalize procedures.
- Task 4: Production of experimental scenario with alternative initial perturbations.
- Task 5: Workshop forum is held and final documentation produced.

5.16.5 Estimate of Time and Costs

6 months, \$25K.

5.17 SOCIAL-DEMOGRAPHIC INFLUENCES ON THE DEMAND FOR AIR TRANSPORTATION

5.17.1 Introduction

Economic, social-demographic, and environmental influences are known to affect the demand for air transportation, but the specific kinds of influences within those broad categories on the demands for various components of air transportation (e.g., passenger, commercial) remain to be determined.

Changes in the major parameters influencing air travel will precipitate changes in patterns of such transportation, and analysis should be undertaken to identify those parameters and to establish quantitative indices between such parameters and the demand for air transportation.

5.17.2 Objective

To identify major influences on the demand for air transportation and to establish quantitative means for projecting changes in that demand.

5.17.3 Approach

The study will focus on one point in time, 1970, among geographical units of the U.S., but longitudinal analyses will be adopted where feasible. The research will involve a synthesis of a number of proven analytical strategies in an effort to extend work already begun in a manner that will have direct implications for policy formation in the area of air transportation demand. Specifically, the analyses will involve the following:

- 1) Extend earlier investigations of the economic, social-demographic, and environmental parameters begun in the scenario-construction phase of the NASA Portable Fuel Project. Parameters have already been identified which are assumed to impact the demand for energy consumption in general. These parameters will be empirically tested and emphasis will be placed on air transportation demand.
- 2) The overall model will follow the perspective of human ecology, that is, the study of ways in which population groupings adapt to demographic, technological, and environmental influences. A sufficient literature exists to aid in modeling these processes.
- 3) As noted above, the analyses will focus on geographical units of the U.S. in 1970. The form of the relationships between selected parameters and air transportation demand will be studied using regression analyses.

5.17.4 Task Description

The contractor will provide the personnel, services, and materials required for carrying out the following specific tasks:

- Task 1: Identify specific measurements of demand for air transportation through a comprehensive review of the relevant literature and through consultation with the engineering and scientific specialists of the Center for Energy Studies at The University of Texas at Austin.
- Task 2: Identify the components of air transportation demand, e.g., commercial, passenger. Ascertain the measurement of these components of air transportation demand.
- Task 3: Specify the most viable geographical unit of the United States for analysis. Depending on the data availability, these units may consist of counties, states Standard Metropolitan Statistical Areas, State Economic Areas, regions, or some combination of these and other units.
- Task 4: Identify the broad range of economic, social-demographic and environmental influences which are major criteria for the demand in air transportation. This identification would follow from an intensive review of the relevant social science, engineering, technological assessment, and related literature.
- Task 5: Conduct correlation analyses to limit these parameters to those which are relatively statistically independent of one another. Issues of multi-collinearity will be addressed at this point.

- Task 6: Regress the revised list of parameters upon air transportation demand in general, as well as upon the components of that demand.
- Task 7: Identify the relationships most central to policy formation.
- Task 8: Provide a complete written report of the full analysis, specifying the magnitude and degree of change in the key parameters influencing air transportation demand.

5.17.5 Estimate of Time and Costs

6 months, \$20K.

5.18 DELINEATION OF POTENTIAL SOCIETAL DISLOCATIONS RESULTING FROM EFFORTS TO ESTABLISH ENERGY INDEPENDENCE IN THE UNITED STATES

5.18.1 Introduction

There is enormous potential for social, economic, political, and demographic dislocations if the United States elects to mount a major effort to become self-sufficient with respect to energy production. The Center for Energy Studies at The University of Texas at Austin will specify the parameters most likely to be significantly impacted by a program such as Project Independence. Cross-impacts and direction of relationships will be specified. The work will utilize and extend existing analyses in delineating general and specific effects. A study designed to identify the significant parameters is necessary before meaningful research can be undertaken to estimate the magnitude of effects because of the tremendous complexity of the problem and because little in the way of systematic analysis has been done thus far.

5.18.2 Objective

To analyze population movements due to changes in energy generating facilities in the U.S.

5.18.3 Approach

The approach will involve bringing together and synthesizing both existing analyses and some original studies of the energy needs, productive potential and requisite delivery systems of the United States in order to predict the dislocations that can be expected to occur concomitantly

with a full-scale effort to reach energy independence. At least six general questions must be addressed:

- 1) What are the current energy needs (by sector) of American society and what changes can be anticipated in the next two to three decades in energy demands?
- 2) What are plausible mixes of energy forms which can meet the demand?
- 3) What is the location of the required resources?
- 4) What are the capital and human resources necessary to develop these resources?
- 5) What is the nature of the dislocations that will occur as a result of a full-scale effort to develop and deliver the greater quantity of energy in an acceptable form?

5.13.4 Task Description

The contractor will provide the personnel, services and material required to carry out the following specific tasks:

- Task 1: Compile and compare existing estimates of current and future energy demand by sector based on reasonable cost and population projections.
- Task 2: Delineate a range of potential strategies and energy mixes for meeting the demand.
- Task 3: Based on information available from government and industry sources, identify as accurately as possible the location and extent of energy resources and reserves (oil and natural gas, shale, coal, fissionable materials, geothermal and hydroelectric).
- Task 4: Specify the social, economic, political, and demographic variables that will be significantly impacted by an expansion of domestic production of energy such as:
 - a) The sectoral and occupational transformation of the labor force.
 - b) The potential for new industry.
 - c) The redistribution of population that will certainly occur in response to variation in economic opportunities.
 - d) The redistribution of service industry (including transportation and communications) that will follow the movement of population.

- e) The growth and mode-shifts in transportation that may be required for efficient delivery of energy.
- f) The nature of the political changes necessary to facilitate growth of domestic production.
- Task 5: Specification of the type of data required to make rigorous estimates of the magnitude of the dislocations and of the capital cost incurred.

5.18.5 Estimate of Time and Costs

6-12 months, \$25-50K.

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APPENDIX A

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